



**INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE**

**REPORT OF
TWENTY SEVENTH MEETING OF THE
COMMUNICATIONS/NAVIGATION AND SURVEILLANCE SUB-GROUP
(CNS SG/27) OF APANPIRG**

Bangkok, Thailand

28 August- 1 September 2023

The views expressed in this Report should be taken as those of the Sub-group and not of the Organization. This Report will be submitted to the APANPIRG/34 Meeting and any formal action taken will be published in due course as a Supplement to the Report of the APANPIRG Meeting.

History of the Meeting**Page**

1.	Introduction.....	i-6
2.	Attendance	i-6
3.	Opening of the Meeting	i-6
4.	Officers and Secretariat.....	i-6
5.	Organization, Working Arrangement, Language and Documentation	i-6
6.	Conclusions and Decisions – Definition.....	i-7

Report on Agenda Items

Agenda Item 1:	Adoption of agenda.....	2
Agenda Item 2:	Review outcomes of 41st Session of ICAO Assembly, APANPIRG, APAC ANSP Committee, ATM Sub-group, MET Sub-group and other Meetings relevant to CNS Sub-group	2
Agenda Item 3:	Aeronautical Fixed Service (AFS).....	3
	3.1. Review Report of the Tenth Meeting of the Aeronautical Communications Services Implementation Coordination Group (ACSICG/10) including:	
	- Report of the Eleventh Meetings of Common aeRonautical VPN Operations Group (CRV OG/11)	
	- Report of CRV Workshop	
	- Report of the first Meeting of CRV OG Ad-hoc Governance Group	
	3.2. Other AFS related issues	
Agenda Item 4:	Information Management (IM).....	8
	4.1 Review Report of the Seventh Meeting of System Wide Information Management Task Force (SWIM TF/7)	
	4.2 Outcomes of SWIM Seminar	
	4.3 Other IM related matters	
Agenda Item 5:	Aeronautical Mobile Communications Service and Aeronautical electromagnetic spectrum utilization.....	11
	5.1 Review Report of the WRC-23 Workshop/RPG Meeting for WRC-2023	
	5.2 Review Report of the Seventh Meeting of Spectrum Review Working Group (SRWG/7)	
	5.3 Update on status of datalink applications and VHF capability sharing by States	

	5.4	Other issues related to aeronautical communications service and aeronautical radio spectrum management, especially on 5G implementation and potential impacts to aircraft radio altimeters	
Agenda Item 6:		Navigation.....	15
	6.1	Review Report of the Tenth Meeting of Performance based Navigation Implementation Coordination Group (PBNICG/10)	
	6.2	Review Report of the Fifth Meeting of GBAS/SBAS Implementation Task Force (GBAS/SBAS ITF/5)	
	6.3	Review Revised Navigation Strategy for the APAC Region	
	6.4	Other navigation related matters	
Agenda Item 7:		Surveillance	20
	7.1	Review Report of Eighth Meeting of the Surveillance Implementation Coordination Group (SURICG/8), including:	
		- Report of the Sixth Meeting of Mode S Downlinked Aircraft Parameters Working Group (Mode S and DAPs WG/6)	
		- Report of the Third Meeting of the Surveillance Study Group (SURSG/3)	
	7.2	Other surveillance related matters	
Agenda Item 8:		Automation	22
	8.1	Review Report of the Fourth Meeting of ATM Automation Systems Task Force (ATMAS TF/4)	
	8.2	Other automation related matters	
Agenda Item 9:		Regional implementation review and updates	23
	9.1	Seamless ANS Reporting Process including the ASBU regional performance dashboard/implementation plan	
	9.2	National ANP and elements related to CNS	
	9.3	Beijing Declaration implementation related to CNS	
	9.4	Contingency Planning for CNS/ATM Infrastructure	
Agenda Item 10:		Review status of CNS deficiencies (APANPIRG Deficiency List)	27
Agenda Item 11:		Capacity Building, including Human Factors and Air Traffic Safety Electronics Personnel (ATSEPs) related training	27
	11.1	Review outcomes of small working group study on human factor issues of ATSEP	

Agenda Item 12:	Cybersecurity of CNS/ATM systems	28
	12.1 Updates on ICAO International Aviation Trust Framework	
	12.2 Other Cybersecurity related issues	
Agenda Item 13:	Innovation and new technologies	28
Agenda Item 14:	Any Other Business	29
Agenda Item 15:	Dates of next Meeting.....	30

List of Appendices

Appendix A:	Asia/Pacific Regional ATN Documentation Tree
Appendix B:	Revised ToR of Aeronautical Communication Services Implementation Coordination Group (ACSICG)
Appendix C:	Asia/Pacific Regional FIXM version 4.2 Extension
Appendix D:	Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material Edition 1.0
Appendix E:	Revised GBAS safety assessment guidance document related to anomalous ionospheric conditions (Edition 2.0)
Appendix F:	Revised SBAS safety assessment guidance document related to anomalous ionospheric conditions (Edition 2.0)
Appendix G:	Revised APAC Navigation Strategy
Appendix H:	General Strategy on Assignment of and Migration to SI Code in the APAC Region
Appendix I:	Mode S DAPs Implementation and Operation Guidance Document v5.0
Appendix J:	Revised ToR of Surveillance Implementation Coordination Group (SURICG)
Appendix K:	Draft version of ICAO APAC Seamless ANS Plan
Appendix L:	Updated List of CNS Related Deficiencies
Appendix M:	Regional Guidance Material for Addressing Human Factor Issues of ATSEP
Appendix N:	CNS Point of Contacts
Appendix O:	CNS SG/27 Action Items

List of Attachments:

Attachment 1:	List of participants	1-1
Attachment 2:	List of working/information papers/flimsies/presentations.....	2-1

History of the Meeting

1. Introduction

1.1 The Twenty Seventh Meeting of the Communications, Navigation and Surveillance Sub-group (CNS SG/27) of Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) was held at the ICAO APAC Regional Office, Bangkok, Thailand, from *28 August to 1 September 2023*.

2. Attendance

2.1 The Meeting was attended by **108** participants (94 In Person + 14 virtual) from **24** States/Administrations (Australia, Bhutan, Brunei Darussalam, China, Hong Kong China, Macao China, France, India, Indonesia, Japan, Lao People's Democratic Republic, Malaysia, Maldives, Mongolia, Myanmar, New Zealand, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, Tonga, USA, Viet Nam), **3** International Organizations namely IATA, IFATSEA and ICAO, including **2** participants from industry partners. The list of participants is provided in **Attachment 1** to this report.

3. Opening of the Meeting

3.1 The Meeting was inaugurated by Mr. Tao Ma, ICAO Asia Pacific (APAC) Regional Director. Mr. Ma extended a warm welcome to all delegates and shared appreciation to the chairpersons of various contributing bodies to the CNS SG. He highlighted significant events, achievements, and progress in CNS since the Sub-group's last Meeting and recent significant developments relevant to CNS under the challenge of COVID-19 in the APAC Region.

3.2 Mr. Richard Wu, the Chair of CNS SG of APANPIRG, welcomed all participants to the first In-Person Meeting of CNS SG being organised after 3 years due to disruption caused by the global pandemic. He congratulated the good work and joint achievements attained by the CNS SG contributory bodies since the Sub-groups' last Meeting. He shared key issues planned for deliberation and consideration by the Meeting and emphasized the safe and reliable CNS infrastructure to support the quick recovery of air traffic along with the need for more collaboration and innovation. He also expressed his appreciation for the strong support and participation from Member States and encouraged Member States to share knowledge, expertise, and experience with the Meeting.

4. Officers and Secretariat

4.1 The Meeting was chaired by Mr. Richard Wu, Deputy Director-General of Civil Aviation, Civil Aviation Department, Hong Kong China. Mr. Luo Yi, Regional Officer CNS, and Ms. Soniya Nibhani, Regional Officer ANS (CNS) Implementation from ICAO APAC Office, acted as the secretaries of the Meeting with the support of Ms. Zhong Wenhan, Regional Officer CNS, and Ms. Varapan Meefuengsart, the Programme Assistant of the same office. The Meeting was also supported by Regional Officers, ATM and MET of the ICAO APAC Office, PBN Officer of the ICAO Regional Sub-Office, Beijing, China, along with Technical Officers from ICAO HQ, Montreal, Canada.

5. Organization, Working Arrangement, Language, and Documentation

5.1 The working language was English, including all documentation and this report. The Sub-group met as a single body to handle all the agenda items.

5.2 The Meeting considered **34** Working Papers, **20** Information Papers, and **10** Presentations. A list of Working Papers, Information Papers, Presentations, and Flimsies is provided in **Attachment 2** to the report.

6. Conclusions and Decisions - Definition

6.1 The Sub-groups of APANPIRG record their actions in the form of Draft Conclusions, Draft Decisions, Conclusions and Decisions with the following significance:

- 1) Draft Conclusions deal with matters which, by the Sub-Group's Terms of Reference, require the attention of States or actions by ICAO following established procedures;
- 2) Draft Decisions relate solely to matters dealing with the internal working arrangements of APANPIRG and its contributory bodies;
- 3) Conclusions: Those Conclusions adopted by the Sub-group on behalf of APANPIRG on technical matters; and
- 4) Decisions relate solely to matters dealing with the internal working arrangement of the Sub-group only.

Note: *In accordance with APANPIRG Procedural Handbook and by Conclusion APANPIRG/29/28: Empowerment to adopt Conclusions and Decisions on purely technical/operational matters by APANPIRG's Sub Groups: Sub-groups are empowered to adopt Conclusions and Decisions on any amendment to Terms of References (ToR), including an extension of time of Working Group/Taskforce formed under relevant Subgroup; and on all technical and operational aspects of Subgroup's work within its ToR. Additionally, APANPIRG Subgroups or Taskforce/Working Groups are empowered to make Conclusions/Decisions related to regional guidance material for publication in ICAO APAC website.*

SN	Reference	Subject	Page
1	Conclusion CNS SG/27/01 (ACSICG/10/01)	- Adoption of the Asia/Pacific Regional ATN Documentation Tree	4
2	Conclusion CNS SG/27/02 (ACSICG/10/04)	- Telecommunication Infrastructure Table	5
3	Decision CNS SG/27/03 (ACSICG/10/06)	- Revised ToR of Aeronautical Communication Services Implementation Coordination Group (ACSICG)	6
4	Draft Conclusion CNS SG/27/04 (SWIM/TF/07/04)	- Asia/Pacific Regional FIXM version 4.2 Extension	9
5	Conclusion CNS SG/27/05 (SRWG/7/1)	- Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material Edition 1.0	13
6	Conclusion CNS SG/27/06	- Revised GBAS safety assessment guidance document related to anomalous ionospheric conditions	17
7	Conclusion CNS SG 27/07	- Revised SBAS safety assessment guidance document related to anomalous ionospheric conditions	17
8	Conclusion CNS SG/27/08	- Extension of the Asia/Pacific GBAS/SBAS Implementation Task Force to complete tasks as per ToRs of GBAS/SBAS ITF	18
9	Draft Conclusion – CNS SG/27/09	- Revised Navigation Strategy- APAC	18
10	Draft Conclusion CNS SG/27/10 (SURICG/8/1 (Mode S and DAPs WG/6/1))	- General Strategy on Assignment of and Migration to SI Code in the APAC Region	21
11	Conclusion CNS SG/27/11 (SURICG/8/2 (Mode S and DAPs WG/6/2))	- Mode S DAPs IGD Edition 5.0	21
12	Decision CNS SG/27/12 (SURICG/8/4)	- Revised ToR of Surveillance Implementation Coordination Group (SURICG)	22
13	Conclusion CNS SG/27/13	- Regional Guidance Document for Addressing Human Factor Issues of ATSEP	27

Report on Agenda Items

Agenda Item 1: Adoption of agenda

Adoption of Agenda (WP/01)

- 1.1 The tentative agenda proposed in **WP/01** was adopted by the Meeting.

Agenda Item 2: Review outcomes of 41st Session of ICAO Assembly, APANPIRG, APAC ANSP Committee, ATM Sub-group, MET Sub-group and other Meetings relevant to CNS Sub-group

Review Outcomes of 41st Session of the Assembly – Sec (WP/02)

- 2.1 The paper briefly summarized the outcomes of the 41st Session of the Assembly related to CNS/ATM implementation for review and action by the CNS SG/27 Meeting. The 41st Session of the Assembly was held at the Montréal Headquarters of the International Civil Aviation Organization (ICAO) from 27 September–7 October 2022. The paper highlighted the main points of Technical Commission Reports, CNS related discussions in Executive Committee Report, and main publications and resolutions of the Assembly.

CNS SG/26 and APANPIRG/33 Conclusions/Decisions, and Action Items- Sec (WP/03)

- 2.2 The Meeting noted the latest status and action taken for various Conclusions/Decisions adopted and recommended in the CNS SG/26, Conclusions/Decisions adopted by the APANPIRG/33 related to CNS, along with the latest status and action taken on various Action Items formulated by the CNS SG/26 Meeting.

Outcomes of the First Meeting of the Asia and Pacific (APAC) Air Navigation Service Provider (ANSP) Committee (AAC/1) – Sec (WP/04)

- 2.3 The paper presented the outcomes of the First Meeting of the APAC ANSP Committee (AAC/1) held at the Regional Office in Bangkok, Thailand, on 17-18 April 2023. The Meeting was informed that the APAC ANSP Committee adopted a framework to organize the work of the Committee into four work streams based on areas of priority. These streams are *step up investments in ANS capacity and capabilities and share requirements and best practices in the procurement of ANS systems; accelerate the development and implementation of Seamless ANS and collaborate on green initiatives to enhance ANS Sustainability; collaborate on business continuity and contingency planning, and formation of an Oceanic Working Group specifically focusing on the operations of the oceanic ANSPs*. Member States/Administrations were invited to coordinate with national ANSP to appoint representatives to the APAC ANSP Committee.

- 2.4 USA shared the significant tasks being done by various streams of AAC, such as contingency procedure development that will support every Member State, and encouraged Member States to join and contribute to the group.

Air Traffic Management and Airspace Safety Monitoring Outcomes – Sec (WP/05)

- 2.5 The paper presented key outcomes of the Tenth Meeting of the Air Traffic Management Sub-Group of APANPIRG (ATM/SG/10) held from 17 to 21 October 2022, the Second Meeting of the South Asia, Indian Ocean and Southeast Asia ATM Coordination Group (SAIOSEACG/2, 20 to 24 March 2023), the Eighteenth Meeting of the Aeronautical Information Services (AIS) – Aeronautical Information Management (AIM) Implementation Task Force (AAITF/18, 19 to 23 June 2023), and Thirteenth Meeting of the ATFM Steering Group (ATFM/SG/13, 03 to 7 April 2023). The Meeting noted that ATM/SG/11, scheduled to be held from 02 to 6 October 2023 in Singapore, will review the outcomes of all the abovementioned Meetings.

2.6 The Meeting noted the need to enhance the communication and surveillance capability of Member States to improve situational awareness, work towards strengthening effective implementation indicators by complying with protocol questions related to CNS, review the NOTAM list, and consider removing old and very old NOTAMs related to CNS, implement AIDC to mitigate LHD incidents, and the need for robust ATC training to ensure the compliance of new technology and the application of contingency procedures when system operation failed.

Review Relevant Outcomes of the MET SG – Sec (WP/06)

2.7 The paper presented relevant outcomes from the Meteorology Sub-Group (MET SG), in particular its contributory body, the Meteorological Information Exchange Working Group (MET/IE WG). The MET/IE WG proposed action to facilitate the implementation of the communication network connections needed to support the required global dissemination of meteorological information in the IWXXM form. The paper highlighted the Draft Conclusion MET/IE WG/21-01: *IWXXM Version Compatibility*, which proposed that States ensure systems are upgraded to support the IWXXM version which complies with the latest amendment to Annex 3, and Draft Conclusion MET/IE WG/21-03: *Global Exchange of IWXXM*, which proposed that the ACSICG prioritizes implementation of network circuits necessary to support the global exchange of meteorological information in IWXXM form. Both conclusions would be presented to MET SG/27 to be held from 04-09 September 2023 in Bangkok, Thailand.

2.8 The Meeting noted that MET/IE WG/21 is conducting a conjoint Meeting session with ACSICG/11 in 2024 to facilitate further regional discussion and progress on the abovementioned matters.

2.9 In response to a query, the Meeting was informed that States are recommended to disseminate MET information in only one version of IWXXM. In addition, States should implement or upgrade the systems for generating, exchanging and consuming IWXXM reports to support the IWXXM version, which complies with the latest amendment to Annex 3 (as stated in the IWXXM compatibility table: <https://github.com/wmo-im/iwxxm/wiki/Package-Compatibility>).

Global Development Related to CNS – Sec (Presentation/01)

2.10 ICAO Secretariat, on behalf of ICAO HQ, shared the presentation to provide the latest status of relevant ICAO SARPs and global development related to CNS and Spectrum.

Agenda Item 3: Aeronautical Fixed Service (AFS)

Review the Report of the Tenth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/10) - Sec (WP/07)

3.1 The paper presented the discussions and relevant outcomes of the Tenth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/10) held at the ICAO APAC Regional Office, Bangkok, Thailand, from 24 to 26 May 2023, along with key outcomes of the ICAO Asia Pacific Idea Generation Workshop: CRV Governance held at the ICAO APAC Office, Bangkok, Thailand, on 31 January 2023 and the Eleventh Meeting of the Common Aeronautical Virtual Private Network Operations Group of APANPIRG (CRV OG/11) held at the ICAO APAC Office, Bangkok, Thailand from 1 to 3 February 2023.

3.2 Mr. Kelepi Dainaki, General Manager Assets & Infrastructure, Fiji Airport Limited, Co-Chair (Pacific) of CRV OG, was elected as Co-Chair of ACSICG.

3.3 The CNS SG/27 Meeting noted the **Decision CRV OG/11/01 - Publish the updated APAC CRV Operations Manual (CRV OG OM v1.2)** and the **Decision CRV OG/11/02 - Update to the CRV Implementation Plan**. The latest version of the documents has been published on [ICAO APAC e-](#)

[docs](#) under CNS, [ICAO APAC CRV Secure portal](#), and on the [CRV portal](#) hosted by Airways New Zealand,

3.4 The proposed Asia/Pacific Regional ATN Documentation Tree, which has been reviewed, updated and endorsed by ACSICG/10, was further updated and adopted by CNS SG/27 through the following Conclusion:

Conclusion CNS SG/27/01 (ACSICG/10/01) – Adoption of the Asia/Pacific Regional ATN Documentation Tree	
What: a. the ATN Technical Document be published in a loose-leaf form to include future amendments to the Document Tree; and b. The ATN Documentation Tree provided in Appendix A of the Report is adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: The current ATN/AMHS Documentation Tree published on the ICAO APAC Website has not been updated for a few years. Therefore, it required updates. Additionally, some documents related to CRV are needed to be added, and others are required to be deleted from the Tree due to obsolete documentation.	Follow-up: ☒ Required from States
When: 01-Sep-23	Status: Adopted by Subgroup
Who: ☒ Sub groups ☒ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☒ Other: CRV OG	

3.5 It was agreed that ACSICG will update the tree every year based on latest development of relevant ICAO documents mentioned in the ATN Documentation Tree. **ACTION ITEM 27-1**

3.6 The Meeting noted the outcomes of the discussion of the ICAO CRV Steering Group formed in the CRV OG/9 to devise the terms and conditions for the addition of new services, upgrade/downgrade of Packages along with the addition of new sites by the CRV contracted States into their contract. The updated documents included the Addendum to Terms And Conditions between PCCW Global and CRV Authority **v3**, High-Level Individual Site Questionnaire **v2.2**, PCCWG System Design Document **v4.6**, and Service Order Form (**v2**), which can be accessed on [ICAO CRV Secure portal](#), and [CRV portal](#) hosted by Airways New Zealand. The Meeting noted that the CRV OG Operations Manual v1.2 has also been updated to incorporate an agreed Addendum to Terms and Conditions between PCCW Global and CRV Authority.

3.7 The Meeting was informed that to close Action Item 9-9 of the CRV OG/9 and Action Item 6-1 of SWIM TF/6, CRV OG/11 adopted the following definition of CRV users in concurrence with MET SG experts.

CRV USER – State/Administration: An entity officially designated by the State to provide the air traffic or air navigation services the State is obligated to provide according to the ICAO provisions.

CRV USER – Industry: An entity not officially designated by the State but authorised by the State to provide aviation or related services commercially.

3.8 It was approved by ACSICG/10 that the State's ANSPs will assign IP addresses to any entities that joined CRV, and all entities will sign their contract individually. Additionally, for the difference in the joining process, CRV Users- State/Administration **will follow the same process as**

mentioned in the CRV OG Operational Manual and CRV Landing Page, while industries will **need sponsorship** by States.

3.9 The Meeting noted the **Conclusion APANPIRG/33/7 - Extension of CRV Contract for one year** and State Letter **Ref.: T 8/2.15 –AP003/23(CNS)** dated 4 January 2023 on the subject: - *Extension of CRV Contract for one year and a reminder for the target year of CRV Implementation by 31 December 2023, in the APAC Region* to inform Member States about the extension of the current contract on same Terms and Conditions and urged to initiate a service order with the PCCW Global for CRV implementation as early as possible, on or **before 31 December 2023** and synchronize the implementation of CRV in the APAC region. States were invited to modify their contract with PCCWG, as required, and initiate a service order with PCCW Global for CRV implementation before 31 December 2023 if not yet joined CRV.

3.10 The Meeting noted a new Package D+, intended to enhance the existing Package D option. The collective modified CRV common Package document agreed for the upgrade/downgrade/addition of new sites and services, and Package D+ is provided on the [ICAO CRV Secure portal](#) and [CRV portal](#) hosted by Airways New Zealand.

3.11 The Meeting noted the latest status of **Conclusion APANPIRG/33/6 - Revised Amendment of the Management Service Agreement for CRV project (RAS14801)**. It was informed that all pioneer Member States countersigned the Revised amended Project Document and provided consent to utilize the remaining funds for the CRV.

3.12 The Meeting noted that the CRV OG/11 and ACSICG/10 Meetings adopted Option 2 - *Penetration test of the PCCWG implementation only* and Option 5 - *Engage a Security consultant to review the Common Package, RFP documentation including the response, Implementation Plan and the Operations Manual and provide a Security recommendation based on this review* by the **Conclusion ACSICG/10/02 (CRV OG/11/03)** – Selection of Security Review Options 2 and 5 and Develop a ToR, for utilization of remaining money from CRV Project. The Meeting also noted the **Conclusion ACSICG/10/03** – Adoption of ToR for CRV Security Review using Options 2 and/or 5.

3.13 The Meeting was informed that CRV OG/11 and ACSICG/10 modified and posted the [Telecommunication infrastructure table](#) on the CRV OG website hosted by New Zealand for members to update. The new table will supersede Table CNS II-2- Required ATN Infrastructure Routing Plan in the ANP VOL II part III. The CRV OG will be the task owner to maintain the table in the future. The following **Conclusion** formulated by ACSICG/10 was adopted by CNS SG/27:

Conclusion CNS SG/27/02 (ACSICG/10/04) - Telecommunication Infrastructure Table			
What: TRACKING TABLE To have a single tracking table with online update capability to support implementing future services managing bandwidth. This table will supersede telecommunication tables maintained by CRV OG and ACSICG.		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: Managing Telecommunication Infrastructure	Follow-up: ☒ Required from States		
When: 01-Sep-23	Status: Adopted by Sub-group		
Who: ☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☒ Other: ACSICG			

3.14 The Meeting agreed to stop updating Table CNS II-1 and II-2 in APAC e-ANP Volume II in the APAC region. All Member States were requested to update the [Telecommunication infrastructure table](#) on priority. **ACTION ITEM 27-2**

3.15 The Twenty-first Meeting of the ICAO APAC Meteorological Information Exchange Working Group (MET/IE WG/21) noted that the capability for inter-regional exchange presented a significant obstacle in progressing the global availability of IWXXM. The lack of global availability of OPMET in IWXXM form is inhibiting system suppliers and users from switching to IWXXM and, therefore, delaying the realization of benefits from implementing IWXXM. MET/IE WG/21 also identified the need for the establishment of inter-regional IWXXM exchange with the MID and AFI regions, alternate (secondary) paths to each region, adequate capacity and bandwidth to support IWXXM exchange, and interconnecting of the CRV with future equivalents in the MID and AFI regions for the global IWXXM exchange to succeed. The ACSICG/10 Meeting supported the MET/IE WG/21 proposal for action on the global dissemination of meteorological information in IWXXM form, and formulated modified the Draft Conclusion CNS SG/27/03 (ACSICG/10/05)- *Global Dissemination of IWXXM*, which is a modification of the proposal by MET/IE WG/21, for further endorsement by CNS SG/27.

3.16 The CNS SG/27 shared its support for the global dissemination of meteorological information in IWXXM format by prioritizing the implementation of intra- and inter-regional aeronautical communication services and network circuits, including support for the implementation of AMHS with File Transfer Body Part (FTBP) and Interpersonal Message Heading Extension (IHE), and facilitating, through inter-regional consultation, the enhancement of inter-regional network redundancy (i.e., primary circuits and backup paths). Yet, the CNS SG/27 observed that a similar titled draft conclusion, with slightly different contents, will also be considered by MET SG/27 for endorsement and further adoption by APANPIRG/34. As the IWXXM dissemination related Conclusion is more relevant to MET SG and to avoid confusion caused by submitting two draft conclusions, with the same title but different contents, to APANPIRG, the Meeting agreed that the proposed draft Conclusion CNS SG/27/03 (ACSICG/10/05) - *Global Dissemination of IWXXM* should be withdrawn, and the ICAO Secretariat would forward the CNS SG's support to MET SG/27 for further follow-up. The Member States were requested to enhance network capabilities to support these requirements. **ACTION ITEM 27-3.**

3.17 The Meeting reviewed and updated the ACSICG ToR prepared by ACSICG/10 and the following Decision was adopted.

Decision CNS SG/27/03 (ACSICG/10/06): Revised ToR of Aeronautical Communication Services Implementation Coordination Group (ACSICG)		
That, The Revised Terms of Reference of the Aeronautical Communication Services Implementation Coordination Group (ACSICG) provided in Appendix B to the Report is adopted.		Expected impact: ☐ Political /Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: The proposed ToR of the ACSICG includes the new direction given by APANPIRG in the fields of Aeronautical Communication Services.	Follow-up: ☐ Required from States	
When: 01-Sep-2023	Status: Adopted by Sub-Group	
Who: ☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☐ APANPIRG ☒ Other: ACSICG		

Current status of CRV Implementation in India – India (WP/34)

3.18 India provided the latest progress of AMHS/CRV implementation within India. India informed that India signed the service contract for the provision of CRV Network with PCCW Global on 15 March 2022, and the actual delivery of CRV Services commenced from 15 December 2022 onwards. India shared the latest State details to whom the International Private Leased Circuit (IPLC) circuits have been replaced and the current status of migration on CRV Network with adjacent States. Further, the Meeting noted the list of States for which the CRV Network is expected to be extended in Q4 of 2023, replacing IPLC circuits.

3.19 India informed that in the year 2018-19, the ICAO Mid Region office was urged to join CRV Network to enable the exchange of AFTN/AMHS/OPMET Data information in IWXXM format with states in APAC regions for Seamless Air Navigation Services (ANS) for the safety of flight operation in the MID and APAC Regions. However, not much progress has been made so far. India suggested extending the existing CRV network to the MID Region to facilitate smooth connectivity and exchange of Aeronautical/meteorological and other traffic from the APAC region. The Meeting and the ICAO Secretariat APAC Office were requested to take up the matter with the MID Region and invite them to join CRV, which will facilitate the setting up of a networking environment within the MID Region, provide smooth connectivity with APAC region and obviate the requirements of IPLC.

3.20 The Meeting invited Pakistan and Singapore to share their intention to establish CRV connections with connected MID States. Singapore supported India's proposal and shared its intention to establish CRV connections with concerned MID States. As Pakistan could not join the CNS SG/27 Meeting, the ICAO Secretariat will coordinate with Pakistan to get their intention to establish CRV connection with connected MID States. The ICAO Secretariat was requested to ascertain the intention of all members with entry/exit points between APAC and MID Regions. **ACTION ITEM 27-4**

3.21 The Meeting supported the suggestion for MID states to join CRV and the potential benefits to both regions. The ICAO Secretariat of the APAC Office was requested to coordinate with the ICAO MID Office, send a letter mentioning the successful experience and benefits of CRV attained by APAC Member States after joining CRV, invite PCCW Global to present significant information about the CRV network and its benefits to MID ATS Messaging Management Centre Steering Group (MIDAMC STG) (equivalent to the ACSICG in APAC Region) **ACTION ITEM 27-5** and encourage MID States to initiate discussion with PCCWG for this process. The ICAO Secretariat will coordinate with the MID office and PCCWG to organize a joint event to share the requested information with MIDAMC STG and other relevant ICAO MID Meetings. **ACTION ITEM 27-6**

Challenges and Requirements for IPS Environment – USA (WP/29)

3.22 The paper addressed challenges and requirements for supporting future services, including SWIM, in an Internet Protocol Suite (IPS) environment. The requirements were suggested from ICAO, network, and user perspectives.

3.23 The challenges shared with the Meeting were as follows:

- Which body will provide support for the management of the IPv6 address space and DNS namespace;
- Which entities should enter into such an agreement, execute governance and oversee the service provision;
- How should competing EMSs within a region be selected and authorized, and;
- Guidelines for sensible use of the ATN and the Internet for SWIM information are needed.

3.24 The ICAO Secretariat informed that the appropriate number of EMSs for regional SWIM is being discussed at the SWIM TF. The selection and authorization of EMS within the region will be the next step after the EMS performance requirements are identified. Additionally, whether SWIM TF should select and authorize EMS within the region would need further deliberation in SWIM

TF. ICAO Secretariat will share the request shared by the paper with SWIM TF. **ACTION ITEM 27-7**

3.25 Furthermore, the Meeting noted that CRV OG is already deliberating on the way forward to efficiently utilize available CRV bandwidth to disseminate obligatory critical aeronautical messages. Further guidelines related to this aspect may be prepared by CRV OG for ACSICG consideration and adoption by CNS SG. The ICAO Secretariat will share the pertinent information mentioned in the paper with CRV OG for further action. **ACTION ITEM 27-8**

3.26 Regarding ICAO requirements mentioned in section 3.1 of the paper, the ICAO Secretariat informed that after CNS SG/25, similar action items were initiated for which ICAO Secretariat coordinated with ICAO HQ relevant panels. ICAO HQ informed about the creation of a new inter-panel task force to address the IPv6 addressing and other related mutual concerns. This may include the global guidelines for IPv6 dedicated address block for fixed service and A/G mobile service. ICAO Secretariat will further coordinate with appropriate ICAO HQ panels to update on the latest developments. **ACTION ITEM 27-9** Additionally, a discussion for managing the IPv6 address space and DNS namespace could be initiated at the ACSICG and SWIM TF Meetings in the future. **ACTION ITEM 27-10** It was anticipated that SWIM TF may consider providing DNS to SWIM subscribers and the possibility of managing their own IPv6 address as SWIM will connect to other IP networks in addition to CRV.

Distribution of XML Based Messages in AMHS and SWIM Environment – USA (IP/14)

3.27 The FAA informed about its plan to support the distribution of Extensible Markup Language (XML) based information using AMHS messaging as an interim step towards transition to a SWIM environment. This effort should support the exchange of XML-based messages such as FIXM and IWXXM. Other plans related to IWXXM-formatted data and a smooth transition to direct SWIM-SWIM exchanges were shared with the Meeting.

Agenda Item 4: Information Management (IM)

Review Report of SWIM TF/7 - Sec (WP/08)

4.1 The paper presented the report of the Seventh Meeting of System Wide Information Management Task Force (SWIM TF/7), held from 09-12 May 2023, for review and action. The SWIM TF/7 was attended by 73 participants from 16 States/Administrations, 2 International Organizations and 1 telecommunication service provider. The SWIM TF/7 Meeting report, working papers, information papers, and other resources can be accessed by [this link](#).

4.2 China, Japan, Singapore, and Thailand jointly presented the updated SWIM TF work program following the expected deliverables from the Task groups and proposed the way forward to be able to meet the 2024 Asia/Pacific SWIM implementation timeline. The SWIM TF/7 Meeting agreed that a group responsible for gathering the guidance materials produced by all the related Task groups and consolidating/editing them into a coherent document for review and adoption by the SWIM TF Meeting in 2024 with the support of the ICAO Secretariat was needed. The SWIM TF/7 adopted the **Decision SWIM/TF/07/01 – Formation of an Editorial Task Ad-Hoc Group for the Asia/Pacific SWIM Implementation Guidance Documentation** was adopted by the SWIM TF/7 Meeting. **China, Hong Kong China, India, Singapore, Thailand, and the USA** volunteered to participate in the Task Group. It was agreed that the editorial task ad-hoc group, led by Thailand, would complete the task in the **one-year** timeline.

4.3 To review the draft guidance materials prepared by the Editorial Task Ad-Hoc Group and provide immediate feedback before presenting final draft materials for the review and adoption of the SWIM TF Meeting in 2024, SWIM TF/7 adopted the **Decision SWIM/TF/07/02 - Additional SWIM TF Plenary Meeting in the 2nd Half of 2023**. The SWIM TF/7 Meeting arranged that the **SWIM TF/8**

would be conducted for **Three (3)** days instead of full plenary with restricted agenda items focused on the drafting of Asia/Pacific regional SWIM implementation guidance documents in continuation to **SWIM Business Requirement Brainstorming Working Session** for **Two (2)** days in November 2023. The agreed dates of the Meeting were **6-10 November 2023**.

4.4 China, Japan, Singapore, and Thailand jointly proposed establishing a **SWIM Implementation Pioneer Group under the SWIM TF** to kick-start the Asia/Pacific regional SWIM implementation based on the SWIM architecture discussed at the SWIM TF/2 Meeting. The SWIM TF/7 Meeting adopted the **Decision SWIM/TF/07/03 – Formation of the SWIM Implementation Pioneer Ad-hoc Group** with deliverables outlined in its Terms of Reference (ToR). **Australia, Hong Kong China, Japan, Malaysia, Republic of Korea, Singapore, Thailand, and IATA** volunteered to join the group.

4.5 Japan presented overviews of the content list of the draft APAC SWIM Technical Infrastructure Profiles document. The SWIM TF/7 Meeting requested Member States and Task 3, 5, and 6 leads to review the *APAC SWIM Technical Infrastructure Profiles- Draft Version* and provide comments/feedback to the Task 2 lead by **31 August 2023**. The Task 2 lead will compile and review all comments and feedback and submit the revised draft document to the **SWIM TF/8** Meeting to be held from 8-10 November 2023. ICAO Secretariat will share the *APAC SWIM Technical Infrastructure Profiles- Draft Version* with CRV OG and ACSICG for their feedback and provide feedback to the Task 2 Lead.

4.6 AMHS/SWIM Gateway Study Group (SWAMWAY SG) presented a draft of AMHS/SWIM Gateway technical specifications in the SWIM TF/7 Meeting.

4.7 The SWIM TF/7 Meeting formulated the following draft Conclusion that was endorsed by CNS SG/27 for APANPIRG/34 adoption.

Draft Conclusion CNS SG/27/04 (SWIM/TF/07/04) – Asia/Pacific Regional FIXM version 4.2 Extension			
What: The FIXM version 4.2 Extension provided in Appendix C to the report be: a) adopted as the Asia/Pacific FIXM version 4.2 Extension; b) uploaded to the ICAO Asia/Pacific Regional Office website for immediate use by Asia/Pacific Administrations, where the capability to do so exists, for cross-border ATFM information exchange and to support ATFM/A-CDM integration; and c) presented to the FIXM CCB for review and publication on the FIXM official website.		Expected impact: ☐ Political / Global ☒ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: To provide the information exchange model necessary to support cross-border ATFM and ATFM/A-CDM integration in the Asia/Pacific Region, in order to support the implementation of performance objectives of the Asia/Pacific Regional Framework for Collaborative ATFM		Follow-up: ☐ Required from States	
When: 1-Sep-23		Status: Draft to be adopted by PIRG	

Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☒ Other: SWIM TF, ATFM SG

4.8 ICAO Secretariat will take necessary action to upload FIXM version 4.2 Extension on the ICAO Asia/Pacific Regional Office website for immediate use by Asia/Pacific Administrations after the proposed draft conclusion adoption if adopted by CNS SG/27 and APANPIRG/34. USA also shared support to coordinate and present FIXM version 4.2 Extension to the FIXM CCB for review and publication on the FIXM official website after the proposed draft conclusion adoption, if adopted by CNS SG/27 and APANPIRG/34.

4.9 China, Japan, the Republic of Korea, and the USA jointly proposed the SWIM Discovery Service (SDS) specification as the regional specification to enable the regional interoperable SWIM Registry. The SWIM TF/7 Meeting noted that the proposed SDS implementation specification document belongs to the FAA. Therefore, a review and a reproduction of the document were required to accommodate the purpose and requirements of the APAC Region. After the document is modified to accommodate all key requirements of the APAC region, it can be presented to the SWIM TF Meeting for adoption as regional guidance. Therefore, Task 5 will work to prepare SDS specifications for the APAC Region.

4.10 The paper described the SWIM Discovery Service (SDS) demonstration between ROK, USA, and Japan. It provided capabilities of SDS, SDS instances used for demonstration, service registry used, topologies between SDS instances, and test cases for the demonstration.

4.11 Hong Kong China presented the updates on the work of Task 6 to identify the catalog of basic data elements to be shared and exchanged via APAC Common SWIM Information Services based on operational needs in APAC. The proposed list of information to be exchanged via Common Flight Information Services, Common Aeronautical Information Services, Common Meteorological Information Services, and Common Surveillance Information Services in APAC was shared with the Meeting. The SWIM TF/7 Meeting noted that the terminology used in the paper to define different types of information services is not formulated by any ICAO panels. It was therefore recommended to name them **Common SWIM Flight Information Services, Common SWIM Aeronautical Information Services, Common SWIM Meteorological Information Services, and Common SWIM Surveillance Information Services** to emphasize that these are SWIM services.

4.12 The SWIM TF/7 Meeting was requested to review the proposed data catalog and provide suggestions on additional information that should be exchanged through APAC Common Information Services. ICAO Secretariat is coordinating with the Secretary of Metrology Sub Group (MET SG), Aerodromes Operations and Planning Sub-Group (AOP SG) and the ICAO Aeronautical Information Services- Aeronautical Information Management Implementation Task Force (AAITF) to request to nominate ATM, MET, and AGA Experts to prepare a comprehensive list of information for Common SWIM Flight Information Services, Common SWIM Aeronautical Information Services, Common SWIM Meteorological Information Services, and a Common SWIM Surveillance Information Services.

4.13 The SWIM TF/7 Meeting discussed the utilization of Mode S DAPs in developing an integrated SWIM service incorporating MET information derived from Mode S DAPs. It was informed that the detailed consideration of exchanging MET information derived from Mode S DAPs through IWXXM should be done in consultation with MET SG (MET/IE WG). ICAO Secretariat will coordinate with the Secretariat of MET SG (MET/IE) to explore options on this matter.

4.14 MET/R WG Ad-hoc Group presented the recent updates on the work to identify and document use cases and user requirements for SWIM-based MET information services supporting ATFM in the APAC region in coordination with other working groups and provided an updated draft version of the regional document for consultation. The SWIM TF/7 Meeting shared that used cases could be potentially included in the Asia/Pacific regional SWIM implementation guidance material, which the Editorial Task Ad-hoc Group is drafting.

4.15 Hong Kong China shared its appreciation to SWIM TF for its significant achievements and commended two ad-hoc groups, *SWIM Implementation Pioneer Ad-hoc Group* and *Editorial Task Ad-Hoc Group for the Asia/Pacific SWIM Implementation Guidance Documentation*, for their contribution to enhancing support to APAC Member States for SWIM Implementation.

Multi-Regional TBO Demonstration - Japan, Singapore, Thailand, and USA (WP/32)

4.16 The joint paper presented an overview of the Multi-Regional TBO Demonstration, a collaborative project undertaken by Japan, Singapore, Thailand, USA, and Canada to validate the TBO concept as well as to showcase the TBO operational values and key capabilities, both operational and technical, required to support TBO. The CNS SG/27 Meeting was encouraged to provide guidance and collaborate on establishing the crucial TBO building blocks, i.e., SWIM and FF-ICE, to support the development and realization of TBO in Asia/Pacific.

4.17 In response to a query, Thailand informed that the MR TBO Demo has been concluded with the live-flight demonstration in June 2023, and at present, there is no plan to conduct any other phase of the MR TBO demonstration. However, another discussion in APAC SWIM TF among the MR TBO ANSP partners to conduct such a demo in Asia/Pacific in the future is going on.

4.18 The Meeting agreed to support the collaboration and coordination between the **SWIM TF** and **FF-ICE Operational Requirements Small Working Group (SWG)** under ATM SG as well as **Workstream 2 - Accelerate the Development and Implementation of Seamless ANS and Collaborate on Green Initiatives to Enhance ANS Sustainability** under Asia and Pacific ANSP Committee (AAC) in building the TBO enablers, i.e. SWIM and FF-ICE, in Asia/Pacific. The Meeting also requested SWIM TF to share with CNS SG the progress on this collaboration toward the goal of implementing TBO in the region.

Outcomes of System Wide Information Management Seminar – Sec (IP/17)

4.19 The paper presented the outcomes of the SWIM Seminar held on 8 May 2023 at the ICAO Asia and Pacific Regional Office, Bangkok, Thailand, for Meeting information. The Meeting noted that the theme of the Seminar was *Asia/Pacific SWIM: Where are We Now?* The Seminar focused on sharing SWIM implementation status across the Asia/Pacific region and aimed to foster the exchange of views on how the ICAO Asia/Pacific SWIM Task Force can best support the regional SWIM Implementation.

Agenda Item 5: Aeronautical Mobile Communications Service and Aeronautical electromagnetic spectrum utilization

Review Report of SRWG/7 - Sec (WP/10)

5.1 The paper presented the report of the Seventh Meeting of the Spectrum Review Working Group (SRWG/7) of APANPIRG was held in the ICAO APAC Regional Office, Bangkok, Thailand, with the hybrid option of video teleconferencing on 15 – 17 February 2023. The Meeting was attended by 58 participants from 17 States/Administrations and 2 International Organizations.

5.2 The SRWG/7 Meeting reviewed a summary of efforts and Conclusions that were adopted to improve the utilization of frequency band 117.975-137 MHz in APAC region, as well as the various efforts for enhancing the utilization of frequency band 117.975 MHz-137 MHz and raised the need to review the necessity to implement 128.95MHz for TIBA. The SRWG/7 Meeting was informed Thailand has already published TIBA into the national ATM contingency plan as required by the Regional ATM Contingency Plan. In case of any changes that will be made to the allotment of TIBA frequency, which should be agreed on as regional basis.

5.3 The SRWG/7 Meeting was presented with an overview of the findings from the global database, supplementing the discussion proposed to review the VHF COM frequency allotment plan for APAC to accommodate new requirements. Simulations of future spectrum requirements have shown that certain allotments were prone to saturation while others were underutilized. Reconsideration on such allotments was proposed for better utilization of the allotments, including to allot the band 122.000-123.675 MHz for TWR, APP (L and I) and ACC (L and I), part of 136.000-136.975 MHz for ACC-U, VOLMET and FIS, part of 136.000-136.975 MHz for use by VDL facilities originally from 128.825-132.025 MHz. Besides, if the reduction of 128.825-132.025 MHz to 129.700-130.875 MHz for AOC, and re-assignment of the current use of 128.825-132.025 MHz for VDL to 136.500-136.975 MHz were acceptable, 128.825-129.700 MHz could be re-allotted to VOLMET, ATIS and ACC-L, and 130.875-132.025 MHz can be re-allotted to ACC-U and FIS.

5.4 With differences spotted in the frequency band allotted to AOC and VDL, China suggested to the SRWG/7 Meeting for further clarification of the current frequency planning, and the draft guidance material would be updated accordingly per the result of the clarification.

5.5 To address the comments and the need to discuss in detail the proposals raised in WP/04 and WP/16 of SRWG/7 Meeting, it was proposed to establish an ad hoc expert group with China as the rapporteur, and Mr. Robert Witzgen, as the advisor, with participation from volunteering States/Administrations. This ad-hoc expert group under SRWG would aim to study the allotment plan, analyse the actual usage of allotment registered in FF, identify areas for improvement and to propose solutions (technical and administrative), explore the potential in reallocating sub-bands/pools, survey the use of TIBA in virtual mode. Bhutan, Hong Kong China, Indonesia, India, Japan, Lao PDR, Philippines, Republic of Korea, Singapore, Thailand, United States and IATA expressed their willingness to participate in the ad-hoc expert group.

5.6 A Survey Questionnaire: *The Necessity to Implement 128.950MHz for Traffic Information Broadcasts by Aircraft (TIBA)* was circulated through State Letter Ref.: T 8/8.6 – AP066/23(CNS) on 3 May, 2023. Replies from 17 Administrations will be processed and reported to SRWG/8.

5.7 The SRWG/7 noted the questionnaire results on introducing 50 kHz channel spacing for ILS and VOR facilities in the APAC Region, which was the outcome from the ad-hoc group formed by SRWG/5 in 2021. Based on the survey results obtained, it was noted that certain States have already implemented or planned to implement the 50 kHz channel spacing for ILS/VOR facilities. While most of these States indicated no issues in implementation/planning, States should ensure the aircraft operating in their airspaces can support the use of 50 kHz channel spacing.

5.8 The SRWG/7 was presented on the latest work, enhancements and functionalities brought to the Frequency Finder (FF) tool to assist ICAO Regional Offices and States/Administrations in managing and coordinating aeronautical frequency assignments and SSR Mode S II/SI codes. The SRWG/7 was informed about the launch of the ICAO Web course on Aeronautical Spectrum Use, with a special focus on VHF, at <https://store.icao.int/en/aeronautical-spectrum-use-with-special-focus-on-vhf-asu-online>.

5.9 The SRWG/7 reviewed the status of Frequency List 2, the list of facilities in the band 108-117.975MHz and 960-1215MHz endorsed in the Third Asia/Pacific Regional Air Navigation (ASIA/PAC/3 RAN) Meeting, and the planned migration of the Frequency List 2 to Frequency Finder (FF) global database like other Frequency Lists. A revised Frequency List 2, to be used as the interim solution, was presented and endorsed by the SRWG/7 Meeting. With this, *Frequency List No.: 2 – Thirty Sixth Edition, March 2023*, which Frequency Finder prepared, was published through State Letter Ref.: T 8/8.4 & T 8/8.5: AP059/23 (CNS) on 17 April 2023.

5.10 It was informed that the in-person workshop for FF will be held on 9-13 October 2023 at the ICAO APAC Office in Bangkok, Thailand for hands-on training on the installation and usage of FF.

5.11 The SRWG/7 reviewed the Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material draft presented by China. The SRWG/7 Meeting noted that this guidance material was not intended to and should not replace the relevant requirements stipulated in Annex 10 and Doc 9718. If there is any inconsistency or conflict between this document and Annex 10 and Doc 9718, Annex 10 and Doc 9718 should take precedence. A State Letter Ref.: T 8/8.9 – AP035/23 (CNS) was circulated on 22 February, 2023, to invite States/Administrations to review the Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material Edition 1.0. Only three replies were received without substantial comments. It was agreed that the Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material will be updated further if any comments/observations were received from Member States. The following Conclusion formulated by SRWG/7 was reviewed and adopted by CNS SG/27.

Conclusion CNS SG/27/05 (SRWG/7/1) - Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material Edition 1.0		
What:	Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material provided in Appendix D to the Report is adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why:	Per discussion from SRWG/7 for the region to utilize the Guidance Material	Follow-up: ☐ Required from States
When:	01-Sep-2023	Status: Adopted by Subgroup
Who:	☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☒ Other: SRWG	

Report of the Workshop on ITU World Radiocommunication Conference 2023 (WRC-23 Workshop) / Regional Preparatory Group (RPG) Meeting for WRC-2023 – Sec (WP/09)

5.12 The paper reviewed the report of the Workshop on International Telecommunication Union (ITU) World Radiocommunication Conference 2023 (WRC-23 Workshop) / Regional Preparatory Group (RPG) Meeting for WRC-2023, which was held from 13 to 14 February 2023 at the ICAO APAC Regional Office, Bangkok, Thailand. The workshop reviewed the requirement of aeronautical frequency spectrum management, summarized the main outcomes of the ITU WRC-19, and highlighted the agenda items related to aviation in WRC-23. The Meeting is invited to note that WRC-23 is scheduled for 20 November - 15 December 2023, in Dubai, United Arab Emirates, ensure active participation in WRC-23 by aviation representatives and support the ICAO position for WRC-23. The Chairperson encouraged members to attend the forthcoming WRC-2023 and express support for the ICAO position.

Report from CP-DCIWG-WG-M/1 Meeting – Rapporteur of CP-DCIWG-WG-M (WP/27)

5.13 The paper presented the progress of the first Meeting of the Communication Panel/Data Communication Infrastructure Working Group-M (Maintenance) (CP-DCIWG-WG-M/1) held virtually from 5-7 June 2023. The main activities and achievements of CP-DCIWG-WG-M/1, which included an endorsement of ToR, amendment and development of AeroMACS Job Card, and VDL M2 & ATN/OSI Job Card, discussions of WG-M work procedure & technical approach, and development of SARPs, manuals, and guidance materials, were summarized.

5.14 The Meeting supported the enhancement of AeroMACS SARPs and Technical Manual and encouraged APAC Member States to participate in WG-M/2 in Bangkok from 23 -27 October 2023.

Space-Based Very High Frequency (VHF) Communication Services – Singapore (WP/30)

5.15 The paper updated the Meeting on the progress of the technical and regulatory studies of space-based VHF communications (voice and data) in the frequency band 117.975 – 137 MHz in International Telecommunication Union (ITU), Future VHF Subgroup (FVSG), Future VHF Subgroup (FVSG), and Proof-of-Concept (PoC) Demonstration. Hong Kong China suggested and the Meeting concurred to (a) note, instead of support, the work of the Job Card in paragraph 2.9 of the paper as the Job Card had been approved by the ANC and (b) to express support for the frequency assignments for proof-of-concept demonstration when the need arises, subject to the same conditions specified in the ICAO Position for WRC-23 Agenda 1.7 (see in paragraph 5.17 below).

5.16 The meeting appreciated the continuous effort of Singapore on this initiative and discussed the compliance of the methods proposed for the regulatory changes to the RR during the CPM with the Updated ICAO Position for the ITU WRC-23 on WRC-23 Agenda Item 1.7.

5.17 The meeting was informed that the Updated ICAO Position for the ITU WRC-23 was circulated by State Letter Ref.: E 3/5-23/60 on 19 July 2023. The **ICAO Position on ITU WRC-23 Agenda Item 1.7** is:

To support a global primary allocation to the aeronautical mobile-satellite (route) service for both the Earth-to-space and space-to-Earth directions in all or part of the frequency band 117.975-137 MHz subject to the following conditions:

- the use of any new AMS(R)S allocation be limited to aeronautical VHF communications for safety and regularity of flight.
- ensure the protection of existing primary terrestrial aeronautical systems in the 117.975-137 MHz band, and not constrain the planned usage of those systems.

The systems shall be planned, implemented and operated in accordance with international Standards and Recommended Practices and procedures established in accordance with the Convention on International Civil Aviation.

5.18 The SRWG chair supplemented that the detailed information on different methods to satisfy the agenda item of ITU WRC-23 is explained in the Report of Conference Preparatory Meeting(CPM) for WRC-23, which is available at ITU website: <https://www.itu.int/md/R19-CPM23.2-R-0001/en>.

Guidance Material on the Protection of Radio Altimeter from Potential Harmful Interference from Cellular 5G Communications – Sec (IP/02)

5.19 The Meeting reviewed Resolution A41-7 “*Support of the ICAO policy on radio frequency spectrum matters*,” adopted by the ICAO Assembly 41st, and noted that the Secretariat has been working with FSMP and the ICAO Middle East Regional Office (MID) Radio Altimeter (RADALT) Action Group (AG) to develop a guidance material to protect radio altimeters from potential harmful interference from new cellular broadband technologies such as 5G. The paper presented the latest draft of this guidance material for comments and endorsement from the Meeting before processing its publication as an ICAO circular this year. The Meeting noted that the RASG would oversee this topic and requested the ICAO Secretariat to keep in view the development and provide updates to the Meeting.

LDACS Development in China (IP/11)

5.20 The paper introduced the progress of the development of the L-band digital aeronautical communication system (LDACS) in China. The Meeting was requested, and China agreed to share further updates in future CNS SG Meetings.

New-Generation AeroMACS Project Progress in China (IP/12)

5.21 The paper presented the new-generation AeroMACS Project Progress in China. China informed that the New-Generation AeroMACS equipment development in China is based on the technical requirements issued by ICAO.

5.22 The Meeting appreciated China's latest updates for AeroMACS and encouraged it to share further updates in future CNS SG Meetings. Additionally, the CNS SG Chair encouraged and China would consider setting up a demonstration booth to present scenarios of AeroMACS applications mentioned in this paper at **the APAC Region Innovation and Capacity Building Symposium** to be held in Hong Kong China, from 14 – 15 December 2023.

Progress on VHF COM Frequency Allotment Plan for APAC Region – China (IP/13)

5.23 China, as the rapporteur of ad hoc expert group established by SRWG/7, presented the latest actions on the APAC VHF COM Frequency Allotment Plan including the analysis of frequency used in the band 117.975 – 137 MHz, suggestion on simplifying the APAC Frequency Allotment Plan by converging the various allotments of sub-services to the main service and considering reducing the AOC band. These proposals will be further reviewed and discussed in the next SRWG meeting in 2024.

Outcome of APG23-6 Meeting – Sec (IP/15)

5.24 The paper presented the outcome of the Sixth Meeting of Asia-Pacific Telecommunity (APT) Conference Preparatory Group for World Radiocommunication Conference 2023 (APG23-6) held on 14-19 August 2023 in a hybrid mode of physical Meeting in Brisbane, Australia.

5.25 The meeting noted under **WRC-23 Agenda Item 10 (Proposals for agenda items for WRC-27)**: An APT view was developed for a WRC-27 agenda item studying bands for identification of IMT in the range 4.4 to 15.35 GHz. This includes the existing Mobile allocation in the band 4.4 – 4.5 GHz, which is directly adjacent to the Radio Altimeter band (4.2-4.4 GHz). Given the outcome of Radio Altimeter/5G compatibility studies focussing on the band below 4.2 GHz, this would cause serious issues, even with an improved-design Radio Altimeter.

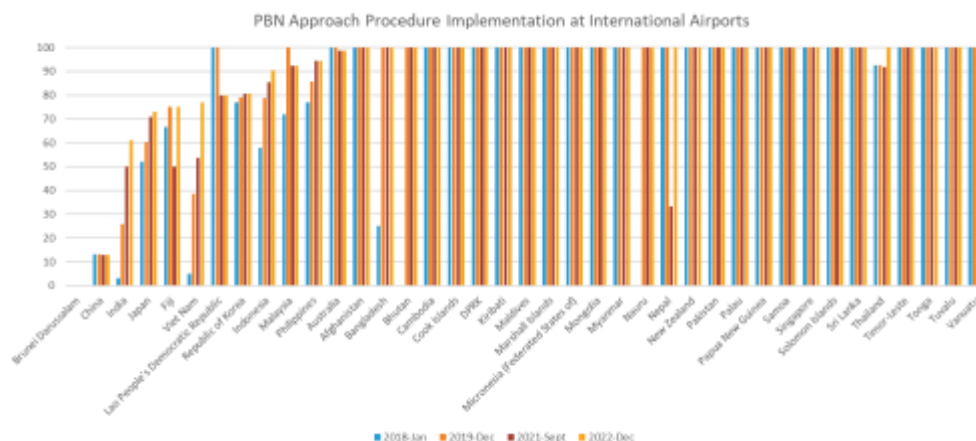
Agenda Item 6: Navigation

Review Report of PBNICG/10 – Sec (WP/11)

6.1 The paper provided information on the outcomes of the PBNICG/10 held in Bangkok from 19-21 April 2023 for review by the Meeting.

6.2 The Secretariat presented global PBN implementation status as available in ICAO iSTARS. ICAO informed that implementation of APV procedures for all instrument runways ends by 2016, the key requirement of ICAO Assembly Resolution A37-11, was behind global achievement. However, PBN SID/STAR implementation was above the global implementation status (see Chart 1).

Chart 1. PBN (Approach) Update, as of Dec 2022 (as per iSTARS)



6.3 The Secretariat informed the PBNICG/10 Meeting that the ICAO Council adopted ICAO SARPs for dual-frequency multi-constellation (DFMC) GNSS in March 2023 to improve overall safety, capacity and efficiency by providing better navigation performance and availability. The DFMC GNSS SARPs will introduce the next generation of GNSS for aviation, such as two entirely new GNSS constellations, Galileo (Europe) and BeiDou (China). The existing SARPs for the GPS (USA) and GLONASS (Russia) constellations are being enhanced to introduce a second frequency and modernized technology and the existing satellite-based augmentation system (SBAS) SARPs are being enhanced to introduce a second frequency and the ability to augment the new constellations.

6.4 The Secretariat informed the PBNICG/10 Meeting that although Baro-VNAV approaches provide significant safety benefits over conventional LOC, NDB and VOR approaches as they provide vertical guidance; however, they are significantly less robust than geometric PBN approaches enabled by SBAS and GBAS as they depend on temperature & QNH setting. The main vulnerability of Baro-VNAV approaches lies in their dependence on the correct altimeter setting, which involves multiple human interventions such as,

- determination of the local QNH by the meteorological service provider,
- publication of the local QNH in ATIS,
- transmission of the local QNH by ATC to the flight crew,
- altimeter setting by the flight crew, and
- correction for the effects of temperature on the atmospheric pressure at aircraft altitude.

6.5 The Secretariat introduced the concept of Established on RNP AR APCH, a procedure for a simultaneous parallel independent approach that takes advantage of RNP AR. The operation considers aircraft stabilized on an RNP AR APCH to be similarly established to aircraft flying an ILS for simultaneous parallel approach separation. Vertical separation is not required between an aircraft “Established” on an RNP AR APCH after a nominated point and an aircraft established on the approach course or track to an adjacent parallel runway. The benefits of EoR are flexibility in the design of simultaneous approach operations, shorter track miles and optimized descent profiles compared to traditional SOIR, increased operational efficiency in terms of runway or airspace capacity and environmental benefits such as a reduction in noise and greenhouse gas emissions.

Review Report of GBAS/SBAS ITF/5 – Sec (WP/12)

6.6 The paper provided information on the GBAS/SBAS ITF/5 outcomes held in Tokyo, Japan, from 21-23 June 2023 for review by the Meeting. The revised GBAS safety assessment guidance

document related to anomalous ionospheric conditions, which the GBAS/SBAS ITF/5 agreed, was reviewed and endorsed by CNS SG/27.

Conclusion CNS SG/27/06 – Revised GBAS safety assessment guidance document related to anomalous ionospheric conditions		
What: That, the revised GBAS safety assessment guidance document related to anomalous ionospheric conditions (Edition 2.0) provided in Appendix E to the report is adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: Major updates to reflect the development of GAST D SARPs and the progress of GBAS development and implementation in the region.	Follow-up:	☐ Required from States
When: 1-Sep-23	Status:	Adopted by Subgroup
Who: ☒ CNS Sub group ☐ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:		

6.7 Additionally, the following Conclusion related to the revised SBAS safety assessment guidance document related to anomalous ionospheric conditions was endorsed by CNS SG/27.

Conclusion CNS SG 27/07 – Revised SBAS safety assessment guidance document related to anomalous ionospheric conditions		
What: That, the revised SBAS safety assessment guidance document related to anomalous ionospheric conditions (Edition 2.0) provided in Appendix F to the report is adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: Major updates to enrich the contents and reflect the progress of SBAS development and implementation in the Region and DFMC SBAS SARPs development.	Follow-up:	☐ Required from States
When: 1-Sep-23	Status:	Adopted by Subgroup
Who: ☒ CNS Sub group ☐ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:		

6.8 The GBAS/SBAS ITF/5 Meeting reviewed the draft guidance documents for GBAS and SBAS Implementation. To enhance the draft guidance document for SBAS Implementation, further review and consolidation of States' inputs was considered necessary. As per the assessment of Leads/Co-Leads of Expert Group, the draft guidance document was anticipated to be ready for final review in 2024/2025, subject to the progress in further enriching the draft guidance document for SBAS Implementation with another round of consolidation.

6.9 The Asia/Pacific GBAS/SBAS Implementation Task Force was initially planned for 3 years, with the last Meeting in 2023. Because of the status of the draft guidance documents for GBAS and SBAS Implementation and the need to spend more time to finish these two guidance documents, the Expert Group considered the need and necessity to extend the period of Asia/Pacific GBAS/SBAS Implementation Task Force for another three (3) years for inputs/comments to be collected from States. The following Conclusion proposed by GBAS/SBAS ITF/5 was adopted by CNS SG/27.

Conclusion CNS SG/27/08 - Extension of the Asia/Pacific GBAS/SBAS Implementation Task Force to complete tasks as per ToRs of GBAS/SBAS ITF		
What: To extend the period of Asia/Pacific GBAS/SBAS Implementation Task Force for another 3 years (i.e., up to 2026) for completing the following remaining tasks with high priority in the Action List and considered essential for fulfilling the objectives stated in the Terms of Reference (ToRs) of the APAC GBAS/SBAS ITF: - GBAS and SBAS implementation guidance documents; - Workshop/Meeting for APAC airspace users and regulators; and - Discussion and deliberation on technical issues in relation to GBAS/SBAS Safety Assessment and Performance Demonstration.		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To complete tasks, such as guidance reference for GBAS/SBAS Implementation, under the TORs of Asia/Pacific GBAS/SBAS Implementation Task Force		Follow-up: ☒ Required from States
When: 1-Sep-23		Status: Adopted by CNS SG
Who: ☒ CNS Sub group ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:		

Revised Navigation Strategy for Asia Pacific Region – Sec (WP/13)

6.10 The paper presented the Navigation Strategy for the Asia/Pacific Region, revised in 2016 by CNS SG/20 and adopted via Conclusion APANPIRG/27/37. The Meeting reviewed and adopted the following Draft Conclusion for adoption in APANPIRG/34.

Draft Conclusion CNS SG/27/09 - Revised Navigation Strategy- APAC		
What: Draft Revised Navigation Strategy-APAC in view of the latest development in GNSS navigation provided in Appendix G to the report is adopted.		Expected impact: ☒ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To update the revised Navigation Strategy-APAC		Follow-up: ☐ Required from States
When: 1-Sep-23		Status: Draft to be adopted by PIRG
Who: ☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☐ Other: -		

Managing Challenges of In-Situ Replacement for Instrument Landing Systems at the World's Busiest Cargo Airport – Hong Kong China (WP/26)

6.11 The Hong Kong International Airport (HKIA) has been the world's busiest cargo airport since its opening in 1998. To support safe and efficient landing of aircraft onto the HKIA under the dynamics in wind direction and speed causing changes in runway landing direction in the same day, operations of the Instrument Landing Systems (ILS) at all runway ends have to be maintained. Taking opportunity of Three Runway System Project at the HKIA, replacement of existing ILS has to be carried out in an in-situ manner for an operating runway. Risk assessment and mitigating measures were implemented to ensure new ILS installation, testing and flight check works would not affect existing

ILS and runway operations.

6.12 The paper was presented in PPT and triggered lots of constructive deliberations and QnAs related to in-situ ILS replacement and Member States deliberated about challenges and potential solutions based on their own experiences. The meeting encouraged CAAs/ANSPs who have undertaken similar in-situ ILS replacement works to share their experience and risk-mitigating measures.

6.13 The Meeting appreciated Hong Kong, China's experience sharing managing risks and challenges of in-situ ILS replacement while keeping existing ILS operations to support HKIA's round-the-clock operations. The meeting commended HKCAD for its innovative, proactive maintenance scheme in operating ILS serving South Runway for some 25 years and still maintaining it in good condition. The meeting also noted the explanation from Hong Kong China on the reason for having underground Glide Path buildings was to comply with Annex 14, which requires frangible structure if the buildings are erected (with associated equipment) above ground within the runway strip, and to minimize obstacles close to the runway.

6.14 The Meeting clarified that specialized computer modelling and simulation had been done in advance as part of the risk assessment and mitigating measures. Flight checks were conducted (1) on the existing ILS with new ILS in place to ensure no adverse impact on the existing operations and (2) on the new ILS with existing ILS in place. A flight check will be conducted on the new ILS right after the existing ILS is dismantled. Besides, the flight procedure associated with the ILS was revisited by the flight procedure designer even though the two systems are located close to each other.

Feasibility Study and Trial of Using Drone to Enhance Efficiency in Flight Inspections at the Hong Kong International Airport – Hong Kong China (WP/33)

6.15 The paper presented the initiative from Hong Kong China, supported by the Flight Inspection Center of the Civil Aviation Administration of China, in exploring the use of drone technology to enhance efficiency in flight inspections and conducting a feasibility study/trial on carrying out part of flight inspections at the HKIA by drone.

6.16 The Meeting noted that a trial was successfully conducted at the HKIA with promising outcomes. The Meeting was informed that the flight profile of the drone was pre-programmed with pre-defined flying routes over the north runway of the HKIA while the drone operator has kept line of sight with the drone throughout the whole process to closely monitor and could take control at any time. Coordination with ATC was carried out in prior to ensure smooth conduct of the trial. The trial was scheduled for favourable weather conditions and low air traffic hours to ensure the stability of the operation. The Meeting noted the initiative by Hong Kong China, to explore drone technology and its application in enhancing efficiency in flight inspection, and encouraged CAAs/ANSPs who have undertaken similar feasibility studies, trials and flight inspections using drones to share their experience. A video link to the trial titled "Civil Aviation Department conducts trial flight inspection by small unmanned aircraft at the Hong Kong International Airport to enhance efficiency" was given at <https://isd.wecast.hk/vod/?>

6.17 China supplemented the practice of using drones in flight inspections. China conducted experiments using 3 types of drones: fixed-wing RPAS with a heavy payload, hybrid-wing RPAS with a medium payload, and multirotor drones with detachable payload. China is proposing with the USA and European countries to setup an ad hoc group under ICAO NSP to update Doc 8071. The Meeting was invited and China agreed to keep CNS SG informed on future progress on this initiative.

Navigational Aids Check by Using Drone in the Republic of Korea – ROK (IP/20)

6.18 The paper provided information about drones' development and practical use in navigational aid checks in the Republic of Korea. The Meeting was informed that aerial inspections using drones, which are being implemented in the ROK, can more efficiently and effectively conduct ground inspections of navigational aids.

6.19 The Meeting noted that the drone was used at night with good weather conditions and a good GPS signal, and the licensed flyer operated the drone. KAC is using the drone for navigational aids check 4 times per year as a supplementary solution to conventional ground check. ROK is working on its national law on drone use for maintenance.

6.20 The Meeting advised members to make assessment on potential impact to and coordination with ATC operations. The Meeting appreciated the experience sharing from ROK and invited ROK to share their development in future CNS SG Meetings.

6.21 Some other reference materials on this topic, including papers from previous ICAO Meetings and some media files, were shared with the Meeting. These reference materials can be accessed by links provided here:

- Trial Flight and Standard Establishment of UAS-Based Flight Inspection in China - [WP/27 of CNS SG/26](#)
- Standard Establishment of UAS-Based Flight Inspection System in China- [Flimsy/03 of CNS SG/25](#)
- Video on [Civil Aviation Department conducts trial flight inspection by small unmanned aircraft at the Hong Kong International Airport to enhance efficiency](#)
- Video on DIVA [\(Drone for ILS VOR Analyzer\)](#) from ROK

BDS Standardization Status in ICAO – China (IP/09)

6.22 China shared the status of BeiDou Navigation Satellite System (BDS) standardization in ICAO, including the BDS SARPs endorsement progress, the BDS related contents in GNSS manual revision, and BDS related requirements development and validation in ARAIM SARPs.

Research on BDS ISM Broadcast Scheme – China (IP/10)

6.23 China shared the status of Advanced Receiver Autonomous Integrity Monitoring (ARAIM) Integrity Support Message (ISM), including the descriptions of ISM and Integrity Support Data (ISD), the ISM design of core constellation (GPS and Galileo), and the research on BeiDou Navigation Satellite System (BDS) ISM broadcast scheme.

Korea Augmentation Satellite System (KASS) Status – ROK (IP/19)

6.24 The paper provided information about the Korean SBAS (KASS) Development and Implementation Status led by the Korean government (MOLIT, the Ministry Of Land, Infrastructure and Transport). The configuration, implementation status, and future plan of KASS were introduced. The Meeting noted that the flight test for APV-I will be conducted in September 2023, and the Sol service signal broadcast is expected from the end of December 2023.

Agenda Item 7: Surveillance

Review Report of the Eighth Meeting of the Surveillance Implementation Coordination Group (SURICG/8) - Sec (WP/14)

7.1 The paper reviewed the outcomes of SURICG/8, including the Sixth Meeting of the Mode S Downlinked Aircraft Parameters Working Group (Mode S and DAPs WG/6) and the Third Meeting of the Surveillance Study Group (SURSG/3).

7.2 The ICAO Aircraft Address and Target Identification in Surveillance Data and Flight Plan Workshop was held at ICAO APAC Regional Office, Bangkok, Thailand, on 6 June 2023. The workshop received 6 comprehensive presentations from contributors and all presentations can be

accessed at <https://www.icao.int/APAC/Meetings/Pages/2023-SURICG8.aspx>.

7.3 Mr. Ho Wee Sin, Deputy Director (Info Air Traffic Management) of the Civil Aviation Authority of Singapore, was unanimously elected as the new co-Chair of the SURICG.

7.4 The Mode S and DAPs WG/6 Meeting reviewed the general strategy for assigning and migrating to SI codes. The following Draft Conclusion endorsed in Mode S and DAPs WG/6 was reviewed and endorsed by SURICG/8. As the strategy will involve coordination with neighboring regions and require high-level support from CAAs/ANSPs in the Region, the SURICG/8 Meeting considered it appropriate to seek further endorsement from CNS Sub-Group and/or APANPIRG. The Draft Conclusion was endorsed by CNS SG/27 for APANPIRG adoption.

Draft Conclusion CNS SG/27/10 (SURICG/8/1 (Mode S and DAPs WG/6/1)): General Strategy on Assignment of and Migration to SI Code in the APAC Region		
What: The General Strategy on Assignment of and Migration to SI Code in the APAC Region provided in Appendix H of the Report is adopted.		Expected impact: ☐ Political / Global ☒ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To synchronize the APAC region on the general principles applied for assignment of and migration to SI codes.	Follow-up: ☐ Required from States	
When: 13-Dec-23	Status: Draft to be adopted by PIRG	
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other: -		

7.5 In addition, the following Conclusion proposed by Mode S and DAPs WG/6 was discussed and endorsed by SURICG/8 and adopted by CNS SG/27:

Conclusion CNS SG/27/11 (SURICG/8/2 (Mode S and DAPs WG/6/2)): Mode S DAPs IGD Edition 5.0		
What: The Mode S DAPs Implementation and Operation Guidance Document Edition 5.0 provided in Appendix I of the Report is adopted		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: Inclusion of new/supplementary content discussed in Mode S and DAPs WG/6.	Follow-up: ☐ Required from States	
When: 1-Sep-23	Status: Adopted by Subgroup	
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other: -		

7.6 The Meeting noted the **Decision SURICG/8/3 (Mode S and DAPs WG/6/3) - Dissolution of Mode S and DAPs Working Group** was discussed and endorsed by SURICG/8.

7.7 The work and progress of updating the coverage charts of ATS Surveillance and Direct Controller and Pilot Communication (DCPC) VHF for the APAC Region were discussed and expected to be incorporated in the next update of the APAC Seamless ANS Plan. States/Administrations were encouraged to work with appropriate parties and/or other States/Administrations to derive plans to address the coverage gaps identified in the coverage charts, and States/Administrations that have not yet responded to the survey were encouraged to contribute relevant information to complete the coverage charts in future updates.

7.8 The paper reviewed regional requirements specified in Table CNS II-APAC-3 in APAC e-ANP Volume II. The SURICG/8 Meeting noted that e-ANP Volume II contains the General Regional Requirements and Specific Regional Requirements related to CNS from Member States. As such, Member States are encouraged to review all facilities listed in Table CNS II-APAC-3 SURVEILLANCE under the Specific Regional Requirements in e-ANP Volume II and provide updates to the ICAO APAC Regional Office as necessary through the PfA Process. The proposed changes to e-ANP Volume II Table CNS II-APAC-3 SURVEILLANCE have been incorporated. The Secretariat and the concerned Member States are requested to formally update the e-ANP Volume II Table CNS II-APAC-3 SURVEILLANCE in due course at the earliest convenience.

7.9 The SURICG/8 Meeting reviewed and adopted the revised ToR of SURICG provided in **Appendix J** to the report and formulated the following **Decision**, which was adopted by CNS SG/27.

Decision CNS SG/27/12 (SURICG/8/4): Revised ToR of Surveillance Implementation Coordination Group (SURICG)		
What:	That, the Revised Terms of Reference of the Surveillance Implementation Coordination Group (SURICG) provided in Appendix J to this paper be adopted.	Expected impact: ☐ Political /Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why:	The ToR from dissolved Mode S and DAPs WG was reviewed and necessary updates were identified.	Follow-up: ☐ Required from States
When:	1-Sep-2023	Status: Adopted by Subgroup
Who:	☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☐ APANPIRG ☒ Other: SURICG	

Implementation of ADS-B verification technologies for the operational surveillance system in Japan (IP/05)

7.10 The paper presented the implementation status of the ADS-B anti-spoofing function used for the ATC system in Japan. The anti-spoofing function consists of the position verification function using TDOA and a supplementary function to detect position jumps using the CPR decoding method. The Meeting noted that JCAB is currently developing the prototype ADS-B ground station with the above anti-spoofing function. The Meeting was informed that this built-in anti-spoofing function is for ADS-B receiving, not for GPS spoofing. The Meeting invited Japan to further update to CNS SG in 2024.

Agenda Item 8: Automation

Review Outcomes of the Seminar on Air Traffic Management Automation System and the Fourth Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (ATMAS TF/4) - Sec (WP/15)

8.1 The paper summarised the discussion in the Seminar on Air Traffic Management Automation System and the work accomplished by the Fourth Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (ATMAS TF/4), which were held at ICAO APAC Regional Office, Bangkok, Thailand, from 27 to 30 June 2023.

8.2 The Meeting was informed that as a follow-up on Action Item 3-1 of ATMAS TF/3, the ATMAS repository has been circulated through State Letter Ref.: T 8/12.18: AP139/22 (CNS) with

Subject – Publication of ATM Automation System Implementation and Operations Guidance Document (ATMAS IGD Edition 1.0) and Establish the Air Traffic Management Automation System (ATMAS) Repository for APAC Region on 21 October 2022, and total 11 updates have been received from States/Administrations. Based on the ATM automation systems status collected, the preliminary analysis of the key performance indicators on the ATMAS Repository has also been summarized for Meeting review.

8.3 The Meeting was informed that the revised draft (Edition 1.3) of the Air Traffic Management Automation System Implementation and Operations Guidance Document (ATMAS IGD) was adopted by ATMAS TF/4 by **Conclusion ATMAS TF/04/01 - ATMAS IGD (Edition 1.3)**.

8.4 To follow up ACTION ITEM 3-2 of ATMAS TF/3, the table of the AIDC repository with current status has been circulated through State Letter Ref.: T 8/3.5: AP135/22 (CNS) with Subject – Validate and Supplement the Table of AIDC Implementation Status in APAC Region on 17 October, 2022. The ATMAS TF/4 Meeting presented the latest repository of AIDC Implementation Status in the APAC region and the preliminary analysis of the current status and invited States/Administrations to review and update if necessary.

Agenda Item 9: Regional implementation review and updates

Progress on APAC Seamless ANS Reporting Portal – Sec (WP/16)

9.1 The paper presented the current development status of the APAC Seamless ANS Reporting Portal. The paper introduced the use of the APAC Seamless ANS Plan Reporting Portal. The Meeting noted that upon the completion of a review of the APAC Seamless ANS Plan, the Reporting Portal will be updated. ICAO APAC Regional Office will inform the region of the arrangement for using the new Reporting Portal. The Meeting was advised that the portal is able to collect data without the output in graphic mode which requires further development by ICAO HQ ICT.

Updates on Regional CNS Requirements in ICAO APAC e-ANP – Sec (WP/31)

9.2 Further to the last CNS SG/25 and CNS SG/26 Meetings, the paper summarized the latest updates by States/Administrations on CNS requirements specified in ICAO APAC e-ANP and reminded States/Administrations to review the data affecting their administration and provide feedback to ICAO on the data's accuracy in requisite format to update the relevant CNS requirements. The Meeting reviewed the Regional e-ANP and its CNS-related Requirements and noted that the ACSICG/10 Meeting agreed to stop the updating of Table CNS II-1 and II-2 in the APAC e-ANP Volume II in APAC region by using the Telecommunication Infrastructure table for better management and coordination. It was also informed that the TABLE CNS II-APAC-1 ATS INTER-FACILITY DATA COMMUNICATION (AIDC) IMPLEMENTATION PLAN has been replaced by the repository of AIDC Implementation Status in APAC region (Table of AIDC Implementation Status in APAC) which now is maintained by ATMAS TF and ACSICG on yearly basis. In addition, SRWG is studying the issues identified in the current frequency allotment plan and exploring handling HF resource utilization, including the review of TABLE CNS II-4 HF Network Designators.

Achieving High Resilience in Sustaining Operations of Critical Aeronautical Infrastructure – Hong Kong China (WP/17)

9.3 Hong Kong, China highlighted that Critical Aeronautical Infrastructure (CAI) needs uninterrupted operations for sustaining round-the-clock provision of air navigation services for flight safety purpose. CAI includes but not limited to air traffic control centres, towers and corresponding equipment rooms, on-airport and off-airport CNS stations, systems and supporting electrical and mechanical (E&M) facilities, such as power supply and air conditioning etc. Any degradation in performance of the systems and supporting E&M facilities of CAI may lead to disruption to its operations and even induce closure of the FIR as the last resort fail-safe measure. Resilience, redundancy and robustness ("3R") are vital factors to consider in the planning, design and

implementation and maintenance of CAI for coping with unexpected emergency circumstances caused by natural disasters or human-induced incident. This paper shared the experience of Hong Kong China in planning, designing, implementing and maintaining Critical Aeronautical Infrastructure (CAI) in achieving high resilience in supporting its round-the-clock operations.

9.4 The Meeting appreciated Hong Kong China's experience sharing, highlighted the importance of power supply system including the battery bank of UPS under proactive maintenance, recognized the close monitoring of HKCAD on the performance of the contracted maintenance service providers, emphasized the reference to the guidance document adopted by the ICAO APAC ATM Automation System Task Force in providing an independent full-fledged Contingency system from another supplier on top of the Main and Fallback systems for ATM Automation System. Upon inquiry, Hong Kong China explained the risk-based approach adopted in balancing the cost against the benefits gained while implementing additional layers of protection for CAI. Considering the significance of service impact by this subject, Hong Kong China suggested the ICAO Secretariat to consolidate relevant experience from States/Administrations into a guidance document for future reference. **ACTION ITEM 27-11**

9.5 The ICAO Secretariat recalled the Assembly Resolution **A41-8: Ensuring the resilience of ICAO CNS/ATM systems and services**, advised that Resilience will be a keyword in the near future on ICAO forums and encouraged CAAs/ANSPs to share their relevant experience in various contributory bodies of CNS SG.

The Importance of Preparation of Emergency Equipment for ATC as Risk Management – Japan (IP/06)

9.6 Japan presented the operation of a Transportable Radar Control System (TRCS) and Emergency VFR system for ATC (EVA), which enabled the early recovery of ATC systems required for the operation of commercial flights after catastrophes such as earthquake, fire, Tsunami, and the training for the early resumption at the airport. It was noted that JCAB also conducts regular and continuing training to enable early recovery when a disaster occurs.

9.7 The Meeting appreciated the sharing by Japan and was informed that the transportable solution is for airport operation only, not for a complete ATM system. The Meeting also recognized the need for regular maintenance and calibration of the contingency system to ensure its availability in emergencies.

9.8 The Meeting was also advised about the importance of a contingency or business continuity plan. Only with the plan in place and exercised the ANSP could ensure continuous operation without interruption. The Meeting also encouraged States to join the work of the third work stream of the APAC ANSP Committee, **“Collaborate on business continuity and contingency planning”**.

Beijing Declaration Implementation in CNS – Sec (WP/18)

9.9 The ICAO Secretariat shared information about the current status of the Minister's commitment to the implementation of technology (CNS) components under Air Navigation Services mentioned in 'Declaration on Asia/Pacific Ministerial Conference on Civil Aviation' also known as Beijing Declaration, which was due to implemented by 2022.

Repository of AIDC Implementation Status in APAC – Sec (WP/22)

9.10 The paper presented the latest repository of AIDC Implementation Status in the APAC region and the preliminary analysis of the current status for Meeting review. A preliminary analysis of the current AIDC implementation status in the APAC region was shared with the Meeting. It was noted that in the APAC region, a total of 21 States/Administrations have already implemented AIDC, 3 States/Administrations updated that the AIDC is still under testing, and 19 States/Administrations have not implemented AIDC yet. Member States/Administrations were invited to continue keeping the ICAO

Secretariat updated on the latest AIDC implementation status/progress/plan.

Asia/Pacific Seamless ANS Plan (the plan) Update – Sec (WP/28)

9.11 The paper presented the Seamless ANS Plan (the plan) related discussion outcomes from the APANPIRG/33 Meeting and a proposed update of the Performance Improvement Plan of the Asia/Pacific Seamless ANS Plan for initial review by CNS SG. A draft proposal for revising the Seamless ANS Plan Section 7 – Performance Improvement Plan was shared for Meeting review. The Meeting noted that the draft Section 7 was presented to the Seventh Meeting of the AOP Sub-Group (AOP/SG/7, Bangkok, Thailand, 03 – 06 July 2023). The proposed revisions of all sections of the Plan will also be presented to the MET and ATM Sub-Groups of APANPIRG for discussion before being presented to APANPIRG/34 for approval under a formal Conclusion. The CNS SG/27 Meeting was invited to review and provide feedback to the Secretariat on the proposed revision of the Seamless ANS Plan, identify Priority 1 ASBU elements identified in the new performance expectations, and comment on a Secretariat proposal to revise the numbering format of performance expectations.

9.12 ICAO Secretariat informed that SWIM TF already shared the following SWIM related ASBUs to be included in the next edition of ICAO APAC Seamless ANS plan as per APANPIRG Conclusion APANPIRG/33/9 “The Asia-Pacific SWIM Implementation Timeframe and inclusion of the Asia/Pacific SWIM Implementation in the Asia/Pacific Seamless ANS Plan”.

Functional Category	Element	Priority
Information	SWIM-B2/1- Information service provision: Requirements for an information service provider to make aviation-related information available as an information service.	2
	SWIM-B2/2- Information service consumption: Requirements for an information service consumer to discover and access aviation-related information provided via information services	2

9.13 ICAO Secretariat added that except SWIM related ASBUs, other ASBUs required Member State's observations, feedback, and consent before CNS SG agreed to incorporate them into the next version of the plan.

9.14 The Meeting appreciated the ICAO's effort in conducting a preview on the Seamless ANS Plan. The Meeting noted that proposed CNS related ASBUs for the next version of the Seamless ANS plan were not yet discussed or consulted with relevant Point of Contact / CNS contributory bodies as per the agreed process in APANPIRG/33 (refer to paragraph 2.14 of WP/28). Therefore, it was impractical for CNS SG to provide comments on proposed modifications related to CNS related ASBUs, new ASBUs to be added in phase 4, or which of the new block 2 ASBUs should be included in new phase 5.

9.15 As a way forward, the Meeting agreed to form a “**CNS related ASBUs review Ad-hoc Group for next edition of Seamless ANS Plan**”, which will review the proposed ASBUs, prepare a list of CNS related ASBUs to include in the plan, share interim report to APANPIRG/34, and seek consent from CNS SG/28.

9.16 **Australia, China, Hong Kong China, India, Malaysia, New Zealand, Singapore, Thailand, and United States** volunteered to join the Ad-hoc Group. Other interested Member States can share email at snibhani@icao.int or yluo@icao.int to join the ad-hoc group.

9.17 The Meeting also requested all Member States to nominate Point of Contact (PoC) to review CNS related updates that will be proposed by Ad-hoc Group and share PoC information with ICAO Secretariat by email at yluo@icao.int or snibhani@icao.int **ACTION ITEM 27-12** Additionally, it was recommended to initiate review of proposed draft version of ICAO APAC Seamless ANS Plan provided in **Appendix K** to the report.

9.18 The Meeting agreed that the available timelines to complete the task are very difficult to accomplish. Therefore, an ad-hoc group will try its best to fulfill the expectations by preparing revised content for providing an interim report to APANPIRG/34. The following high-level plan was prepared for further action:

SN	Task	Responsible Parties	Tentative Timelines (2023)
1.	ICAO Secretariat preliminary editorial review, and inclusion of new element	ICAO Secretariat	Completed
2.	Formation of CNS related ASBUs review Ad-hoc Group for Next Edition of ICAO APAC Seamless ANS Plan	CNS SG/27	1 September
3.	Issuing email to Member States to join the Ad-hoc Group, advise their PoC, and share commitment to update on Next Edition of Seamless ANS Plan	ICAO Secretariat	7 September
4.	Sharing brief information about To-do work by email	ICAO Secretariat	15 September
5.	Online Meeting to review the background and list of ASBUs to include in the Seamless ANS Plan	ICAO Secretariat CNS ASBUs review Ad-hoc Group	30 September
6.	Consolidate initial comments from Ad-hoc Group and preparation of the list of CNS related ASBUs	ICAO Secretariat	7 October
7.	Issuing State Letter to Member States for reviewing the list of CNS related ASBUs for Next Edition of Seamless ANS Plan	ICAO Secretariat	10 October (3 Weeks State Letter response time)
8.	Compilation of Member States' response and sharing with CNS ASBUs review Ad-hoc Group	ICAO Secretariat	17 November
9.	Online Meeting to review the initial list of ASBUs	ICAO Secretariat CNS ASBUs review Ad-hoc Group	25 November
10.	Prepare an interim updates to APANPIRG/34	ICAO Secretariat	APANPIRG/34 (11-13 December 2023)

Agenda Item 10: Review the status of CNS deficiencies (APANPIRG Deficiency List)

Review Status of CNS Deficiencies – Sec (WP/19)

10.1 The paper presented the list of Air Navigation Deficiencies in the CNS field, which was reviewed in APANPIRG/33. The only outstanding issue was related to the unreliability of AFS communication between Afghanistan and Pakistan. The current List of Air Navigation Deficiencies in the CNS field was reviewed in CNS SG/27 and is provided in **Appendix L** to this Report. As International organizations, such as IATA, would also receive the implementation issues reported by Members, which are related to CNS, the Secretariat also invited inputs from Member States/Administrations and international organizations to explore a way to enhance the ANS implementation in the region by identifying and addressing ANS deficiencies.

Agenda Item 11: Capacity Building, including Human Factors and Air Traffic Safety Electronics Personnel (ATSEPs) related training

Review Outcomes of Small Working Group Study on Human Factor Issues of ATSEP – IFATSEA & Sec (WP/20)

11.1 The paper presented the regional ATSEP human factor guidance document for adoption and the efforts taken to improve the presentation of the guidance material and ease of use by the States. The revised ICAO ATSEP human factors guidance document provided in **Appendix M** to the Report was reviewed and adopted by CNS SG/27 Meeting through the following Conclusion.

Conclusion CNS SG/27/13 - Regional Guidance Document for Addressing Human Factor Issues of ATSEP		
What:	a) ICAO APAC Guidance Document for Addressing Human Factor Issues of ATSEP provided in Appendix M is adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why:	The Guidance document is prepared for the improvisation of existing human resource management process towards ATSEP for addressing the factors adding stress and fatigue, improve their job performance and for achieving organizational resilience and cost benefits.	Follow-up: ☐ Required from States
When:	1-Sep-23	Status: Adopted by Subgroup
Who:	☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☐ Other: XXXX	

11.2 Hong Kong China suggested and IFATSEA agreed to update the guidance document's contents continuously. For example, it is worth considering incorporating the increasingly popular model to include the roles of supervisory and managerial roles of engineers who work with service providers and ensure their performance within the scope of activities as defined in DOC 10057. **ACTION ITEM 27-13**

11.3 IFATSEA informed the Meeting that human factors guidance material will be promoted in the other regions and in the ICAO Assembly in the coming days. **ACTION ITEM 27-14** Currently, ICAO Annex 1 Personal licensing does not mention licensing requirements and procedures for ATSEP. IFATSEA will be initiating actions in the future with the goal of including licensing requirements of ATSEP into ICAO Annex 1.

Implementation Support Project in Lao People's Democratic Republic (Lao PDR) ATM Infrastructure Operations Capability Building – Sec (WP/21)

11.4 The paper summarized the work accomplished by the Implementation Support Project in Lao People's Democratic Republic (Lao PDR) - ATM Infrastructure Operations Capability Building *from October 2022 to May 2023*. The project was managed by the ICAO APAC Office through online coordination Meetings held on a weekly basis. 4 SMEs from ATMB provided onsite support activities in two packages, which covered 11 CNS systems on 7 sites and 55 technicians of LANS under 4 subjects, including Radar and ADS-B, VCCS, AIS/AMHS/Network switch, and ATMAS. A Technical Evaluation Report was produced which summarized the project background and work plans, provided a more comprehensive and systematic analysis of CNS implementation in LANS from technical performance, maintenance level and impact on the ATC operation perspective, and proposed recommendations for future decisions making regarding technical, investment, human resource, and management policy.

11.5 Lao PDR appreciated the ICAO Secretariat's persistent support for capacity building and prompt provision of technical support. China appreciated the ICAO APAC Office, DCAL, LANS for this collaborative project. With the guidance of the ICAO Regional Office and the joint efforts of both sides, all parties achieved fruitful results together through this project. China shared a willingness to participate in the activities and carry out more extensive technical exchanges and strategic cooperation with Member States in the Asia-Pacific region.

ATSEP Competency Based Training in ATMB and CAAC – China (IP/08)

11.6 The paper provided information on the Air Traffic Safety Electronic Personnel (ATSEP) competency-based training in ATMB and CAAC and presented the development of ATSEP training by the example of a training organization in Southwest ATMB.

Technical Assistance Project ATM Infrastructure Operations Capability Building – Lao PDR (IP/18)

11.7 The paper introduced the Implementation Support Project in Lao People's Democratic Republic (Lao PDR) provided by the ICAO, which was managed and implemented by the ICAO APAC Office. The Meeting noted that the project not only enhanced the knowledge and skills of Maintenance technicians with standards and built confidence in technicians but also identified the problem, provided the solutions, and tightened cooperation for further assisting between technicians and ATMB Experts.

Agenda Item 12: Cybersecurity of CNS/ATM systems

Update on Trust Framework Activities - the Secretary of the Trust Framework Panel (IP/16)

12.1 The paper provided an update on ICAO's activities regarding the trust framework, focusing on establishing the Trust Framework Panel (TFP), its work program, and the outcomes of the panel's first Meeting in April of 2023. The Meeting reviewed the approved Terms of Reference (ToRs) for the Trust Framework Panel and the revised job cards. The Meeting was informed that the first Meeting of the TFP was held in person at ICAO Headquarters from 27-31 March 2023. Based on the job cards, the panel agreed to organize itself into three working groups to deliver on the work program, which included a Working Group on Identity Management, a Working Group on Information Security, and a Working Group on Trust Framework Considerations. The TFP will meet as a working group from 30 October to 2 November 2023, and the second Meeting of the TFP (TFP/2) is tentatively scheduled for April 2024.

Agenda Item 13: Innovation and New Technologies

Uniting the Strength of Innovation for Building a Seamless Sky - the Asia Pacific

Region Innovation & Capacity Building Symposium 2023 (APICS 2023) – Hong Kong China (WP/23)

13.1 The paper highlighted the initiatives by China and Hong Kong China, supported by the ICAO Regional Office, in organizing APICS 2023 to support the ICAO core strategy in innovation and global initiatives in capacity building. It encouraged States/Administrations and interested organizations/companies to support, participate as well as attend and/or exhibit in the Symposium and share the information with relevant organizations/companies who would be interested. The Meeting was informed that APICS 2023 had set the theme “**Uniting the Strength of Innovation for Building a Seamless Sky.**” It will host keynote speeches and panel discussions from experts on innovation and capacity building, with leading global industry partners assembling and showcasing their latest innovative solutions and capabilities via exhibitions, demonstrations and talks. With the support from the ICAO Regional Office, APICS 2023, to be held in AsiaWorld-Expo, will be convened between the coming APANPIRG/34 and RASG-APAC/13 Meetings in Hong Kong, China on 14 - 15 December 2023. Further details and registration information for APICS 2023 can be accessed at <https://www.apics2023.org>.



Update on the Implementation of the ICAO Secretariat Strategy on Innovation – Sec (IP/04)

13.2 The paper presented an overview of the actions undertaken under the scope of the implementation of Resolution A40-27 - *Innovation in Aviation* and highlighted upcoming initiatives of relevance to the Middle East Region, which will span across the 2023-2025 triennium. The Meeting was invited to consider the involvement in the actions outlined for the 2023-2025 triennium, in particular, participating in the Innovation Workshop (online) for the APAC Region on 6 and 7 September 2023, as well as the ICAO 2024 Innovation Fair to be held in Montréal, Canada, from 12 to 14 March 2024, and consider supporting the development of the ICAO Innovation Portal.

The Long-Term Vision for the Future Air Traffic Systems of Japan (CARATS) – Japan (IP/07)

13.3 The paper introduced JCAB's measures, especially for responding to the increase in air traffic and Decarbonization through the long-term vision for Japan's future air traffic system, namely Collaborative Actions for Renovation of Air Traffic Systems (CARATS). The Meeting noted that to make a balance between the increase in air traffic and the reduction of CO₂ emissions, JCAB is implementing overall air traffic optimization and improvement for each flight phase in anticipation of future developments in air navigation systems and technological development trends. The CNS SG Chair encouraged and Japan agreed to keep the CNS SG informed of the latest development.

Agenda Item 14: Any Other Business

Comments/Feedback on Asia Pacific Ministerial Declaration on Civil Aviation (Delhi) – Sec (WP/24)

14.1 The paper provided information about convening the Second Asia Pacific Ministerial Conference on Civil Aviation (APACMC/2) in Delhi, India, in 2024 and requested Member States to provide comments on the draft Asia Pacific Ministerial Declaration on Civil Aviation (Delhi). The Meeting noted that the Draft Asia Pacific Ministerial Declaration on Civil Aviation (Delhi) prepared by the Asia Pacific Ministerial Conference Preparation Working Group (MCP WG) was shared with the APAC Member States by ICAO State Letter Ref.: SN 4 – AP104/23 (RD) dated 23 June 2023 for comments/feedback before 15 September 2023. The APACMC/2 to be held in Delhi, India, has been postponed to 2024 and the ICAO APAC Office will share further updates about new dates and other relevant information in due course.

CNS Points of Contact – Sec (WP/25)

14.2 The Meeting reviewed the CNS Points of Contact of Member States listed at the APAC Regional Office and requested States/Administrations to update points of contact of CNS contingency planning and administrative support for effective and efficient coordination in the CNS aspect by sending an email to the ICAO APAC Regional Office at apac@icao.int. The updated CNS Points of Contact are provided in **Appendix N** to the Report.

The CNS SG/27 Meeting Action Items

14.3 There were **fourteen (14)** action items identified in the CNS SG/27 Meeting. The summary of action items is provided in **Appendix O** to this Report.

Agenda Item 15: Date of next Meeting

CNS Meeting Planning for 2024 - Sec (IP/03)

15.1 The paper shared the following tentative schedule for the CNS contributory bodies' Meetings to be held in 2024 for Meeting information and action. The ICAO Secretariat will inform Member States about the exact dates, mode and venue of the Meeting while issuing invitation letters in due course.

Meetings Plan for 2024				
No.	Name of Meeting	Dates (in 2024)	Mode of Meeting	Location
1.	CRV OG/12	23-26 January	In-Person	Nadi, Fiji (tentative)
2.	SRWG/8	March	In-Person	Bangkok
3.	SURSG/4	After completion of the joint event (demo/Trial)	In-Person	Hong Kong China
4.	PBNICG/11	March	In-Person	Bangkok
5.	GBAS-SBAS ITF/6	April	In Person	Bangkok
6.	SURICG/9	April	In-Person	Bangkok
7.	One day SWIM Activity+ SWIM TF/9	13-17 May	In-Person	Bangkok
8.	ACSICG/11	May	In-Person	Bangkok
9.	ATMAS TF /5	June	In-Person	Chengdu, China
10.	CNS/SG/28	1-5 July	In-Person	Bangkok

Note of appreciation

15.2 On behalf of the CNS SG, Mr. Richard Wu, the CNS Sub-group Chair, thanked the ICAO Secretariats for their excellent support and dedication in ensuring the smooth running of the CNS SG/27 Meeting.

15.3 Mr. Richard Wu expressed his appreciation to all participants from Member States/Administrations, International Organizations, and sponsoring industries, including CETC Northwest, Chinney, Frequentis, LES, Saab, and Thales, for their significant contributions and active participation in making the Meeting a successful and fruitful one. Mr. Wu summarized the CNS Sub-group's achievements in this Meeting while highlighting the key issues discussed and addressed.

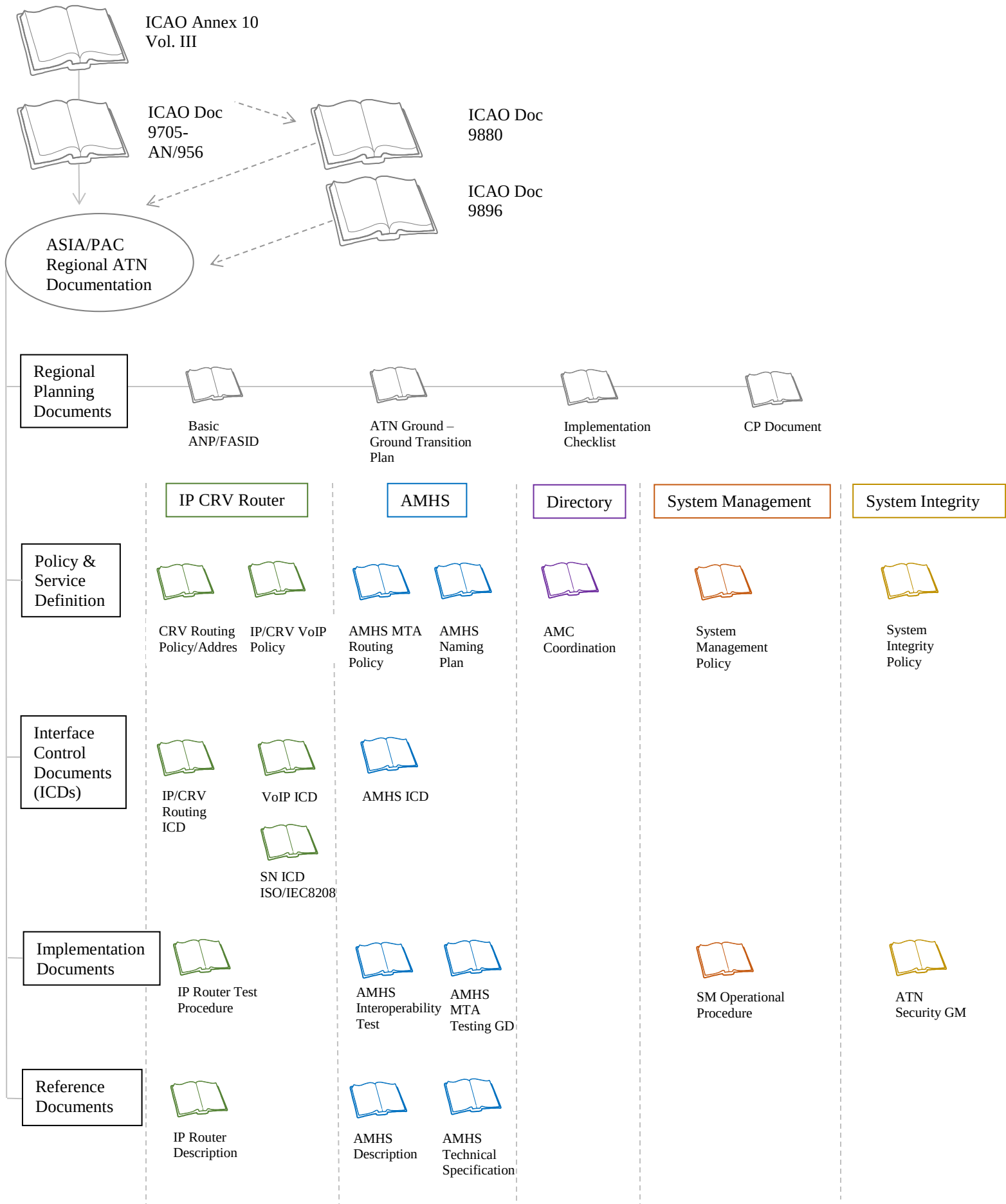
15.4 The Meeting extended sincere gratitude to Mr. Hoang Tran, FAA, for his dedication and contributions towards the planning and implementation of Aeronautical Communications

Infrastructure and Services in the APAC Region as the Chairperson of Aeronautical Telecommunication Network (ATN) Implementation Coordination Group of APANPIRG (ATNICG) from May 2006 to March 2013 and as the Chairman of Aeronautical Communication Services Implementation Coordination Group of APANPIRG (ACSICG) from May 2014 to June 2023.

15.5 The Meeting also shared appreciation to Mode S and DAPs WG for accomplishments of reviewing, identifying and addressing significant issues in technical, operational and regulatory aspects to facilitate the Mode S and DAPs implementation, ensuring harmonized performance of Mode S and DAPs in the APAC Region according to Surveillance Strategy, and promoting the implementation of Mode S and DAPs application.

15.6 The ICAO Secretariat appreciated Mr. Richard Wu, the Chair of the CNS Sub-group, for operating the CNS SG/27 Meeting promptly and efficiently. Lastly, the ICAO Secretariat expressed its gratitude for the contribution and support from APAC Member States, international organizations, and industry partners.

CNS SG/27
Appendix A to the Report



NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

1. The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

a) ~~Text to be deleted is shown with a line through it.~~	text to be deleted in
b) New text to be inserted is highlighted with grey shading.	new text to be inserted in
c) ~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

REVISED TERMS OF REFERENCE FOR AERONAUTICAL COMMUNICATION SERVICES IMPLEMENTATION CO-ORDINATION GROUP (ACSICG)

The Objectives of the APAC ACSICG are to:

- 1) Complete implementation of Asia and Pacific **Regions** (APAC) Aeronautical Telecommunication Network (ATN) and voice/data service to support the evolving ICAO operational requirements for the dynamic exchange and management of aeronautical information.
- 2) Ensure continuous and coherent development of the aeronautical communication services and infrastructure of the Asia/Pacific Regional Air Navigation Plan (APAC ANP) in a manner that is harmonized with adjacent regions, consistent with ICAO SARPs, the Global Air Navigation Plan and the Global Aviation Safety Plan.
- 3) Facilitate the implementation, enhancements, operation and maintenance of aeronautical communication services and infrastructure identified in the Aviation System Block Upgrades (ASBU) elements and Asia/Pacific Seamless Air Navigation Service (ANS) Plan (APSAP) elements using the project management principles where appropriate.
- 4) Review, identify and address major issues in technical, operational, safety and regulatory aspects to facilitate the implementation or provision of safe, secure, efficient and orderly aeronautical communication services to enhance systems robustness, resilience, interoperability and cybersecurity.
- 5) Encourage collaboration among ANSPs and keep abreast of the latest developments in aeronautical communication services and infrastructure to cope with forthcoming development and implementation so as to reduce operating costs and enable quick implementation of new requirements to cope with new challenges.

Deliverables to meet the Objectives:

- 1) To submit progress report to the ICAO APAC CNS Sub-group while keeping ATM Sub-group , MET Sub-group informed of addressing the APAC ACSICG deliverables (listed in 2 to 7 below);
- 2) To support the ICAO in making specific recommendations and developing guidance materials, such as general/specific regional requirements, which aim at facilitating the implementation or

provision of safe, secure and performance based aeronautical communication services by the use of existing and/or new procedures, facilities and technologies;

3) To review outcome of the AN-Conf., DGCA Conference, APANPIRG and its contributory bodies, ~~CNS Sub-group, ATM Sub-group, MET Sub-group, RASMAG, FIT Asia, SWIM TF and ATMAS TF~~ related to aeronautical communication services and infrastructure, revise and update a tasks list and action items for the ACSICG;

4) To facilitate and coordinate the implementations of aeronautical communication services and infrastructures within the Asia/Pacific Regions to support existing and evolving aeronautical applications, including

- inter-facility communications,*
- datalink implementations,*
- air/ground communications*
- ground/ground communications*
- etc.*

5) To Monitor the progress of aeronautical communication service and infrastructure implementation and provide regular updates ~~to stakeholders.~~

6) To provide guidance on the implementation of aeronautical communication services in accordance with relevant standards and regulations, facilitate sharing of information and recommend the best industry practice to Asia/Pacific States and aviation stakeholders on the progress of the development, standardization, and implementation of ICAO provisions relating to aeronautical communication services and infrastructures.*

7) To encourage research and development, trials and demonstrations of applications and technologies, and, as necessary, steer for the sharing of this information and expertise between States/Administrations through organizing educational seminars and symposia to educate States/Administrations and airspace users;

8) To formulate draft Conclusions and Decisions relating to matters in the field of aeronautical communication services that come within the scope of the APANPIRG, ~~CNS Sub-group, ATM Sub-group, and RASMAG~~ work plan;

9) To develop Asia/Pacific regional input and suggestions relating to the implementations and global standardization of aeronautical communication services and infrastructures to be submitted through the CNS Sub-group for APANPIRG consideration and endorsements, in support of ICAO technical panels' developments and implementations of ICAO SARPs; and

10) To collaborate with relevant international organizations (such as EUROCONTROL) for harmonisation of aeronautical communication services and infrastructures requirements.

Timeframe for Deliverables:

For deliverable items, the guidance materials and progress reports would be developed, updated/enhanced on an on-going basis and be made available as appropriate subject to review by the ACSICG. The life time of the ACSICG would be subject to review against the implementation and operation of all identified aeronautical communication services.

Meeting:

The APAC ACSICG shall convene annually, to review progress and address any issues that arise during implementation, at least one face-to-face meeting per year, which is supplemented by teleconference meetings (e.g. MS Teams, ZOOM or WebEx) as appropriate.

Membership:

All APAC member States/Administrations providing air navigation services in the Asia and Pacific Regions. APAC members should nominate Subject Matter Experts from Civil Aviation Authorities, ANSPs, and other organizations with strong background in engineering and operation in relation to aeronautical communication services and infrastructures requirements to participate into the ACSICG. The ACSICG would also invite representatives of International Organizations recognized by the ICAO Council and Industry partners as required by the group which as-representing important civil aviation interests to participate in its work in a consultative capacity.

Reporting

The Group will present its report to APANPIRG through the CNS Sub-group.

Note:

**ICAO provisions mainly refer to the following*

*ICAO Annex 10;
Doc 9869: Performance-based Communication and Surveillance (PBCS) Manual;
Doc 9880: Technical Specifications for ATN using ISO/OSI Standards and Protocols;
Doc 9896: Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol;
Doc 10037: Global Operational Data Link (GOLD) Manual
Doc 9673: Asia and Pacific Air Navigation Plan
Doc 7030: Regional Supplementary Procedures;
Doc 9750: Global Air Navigation Plan (GANP), <https://www4.icao.int/ganportal/>
Doc 10004: Global Aviation Safety Plan (GASP)
Asia/Pacific Seamless Air Navigation Service (ANS) Plan (APSAP)*

FIXM version 4.2 Extension Data Attributes

Data Attribute	FIXM version 4.2
<i>Originally included in the Asia/Pacific FIXM version 4.1 Extension</i>	
ETO (Estimated Time Over)	Core
ELDT (Estimated Landing Time)	Core
CTOT (Calculated Take-Off Time)	Core
CTO (Calculated Time Over)	Core
CLDT (Calculated Landing Time)	Core
TOBT (Target Off-Block Time)	Extension
TSAT (Target Start-up Approval Time)	Extension
TTOT (Target Take-Off Time)	Extension
AOBT (Actual Off-Block Time)	Extension
ATO (Actual Time Over)	Extension
Trajectory • ATO • Flight level or Altitude • Position (Designator or Latitude/Longitude or Relative point)	Extension
Aircraft Track • Ground speed • Flight level or Altitude • Heading • Position (Designator or Latitude/Longitude or Relative point or NAVAID or Aerodrome) • Time over position (Report time)	Extension
<i>Newly identified</i>	
EIBT (Estimated In-Block Time)	Core
TIBT (Target In-Block Time)	Extension
TTO (Target Time Over)	Extension

APAC XSD Description

Namespace	Description
Apac	FIXM Extension containing data attributes to support cross-border Air Traffic Flow Management (ATFM) operations and the integration between ATFM and Airport-Collaborative Decision Making (A-CDM), in accordance with Distributed Multi-Nodal ATFM Network concept and the Airport-Collaborative Decision Making operations in the Asia/Pacific region.

Class	Definition	Reference/Remark
ApacDepartureType	Class containing ATFM data related to departure aerodrome	This class is to be included in extension field under Departure Type class.
Data Attribute	Definition	Reference/Remark
actualOffBlockTime	A time the aircraft is pushed back / vacates parking position (equivalent to airline/handlers ATD – Actual Time of Departure and ACARS=OUT)	ICAO Doc 9971 Manual on Collaborative ATFM, 3rd Edition, 2018
targetOffBlockTime	A time that an Aircraft Operator or Ground Handler estimates that an aircraft will be ready to receive start-up approval/push-back clearance	ICAO Asia/Pacific Regional Framework for Collaborative ATFM, Version 4, October 2022
targetStartupApprovalTime	A time provided by ATC taking into account TOBT, CTOT, and/or the traffic situation that an aircraft can expect start-up/push back approval	ICAO Asia/Pacific Regional Framework for Collaborative ATFM, Version 4, October 2022
targetedTakeOffTime	A time that an aircraft is targeted to be airborne, taking into account TOBT, TSAT, and other factors such as EXOT, wake turbulence, SID, etc.	- ICAO Asia/Pacific Regional Framework for Collaborative ATFM, Version 4, October 2022 - EUROCONTROL A-CDM Implementation Manual, Version 5.0, March 2017

Class	Definition	Reference/Remark
ApacArrivalType	Class containing ATFM data related to destination aerodrome	This class is to be included in extension field under Arrival Type class.
Data Attribute	Definition	Reference/Remark
targetInBlockTime	A time, calculated by an automation system, that an aircraft is expected to be at its first parking position	This time value is not EIBT (Estimated In-Block Time) – The estimated time that an aircraft will arrive in blocks (Ref. EUROCONTROL A-CDM Implementation Manual, Version 5.0, March 2017)

Class	Definition	Reference/Remark
ApacAircraftTrackType	Class containing aircraft track data	This class is to be included in extension field under Flight Type class.
Data Attribute	Definition	Reference/Remark
speed	Current aircraft speed	speed can be in the following forms, • Ground speed; and/or • Indicated airspeed
level	Current flight level	level can be in the following forms, • Flight level; or • Altitude.
heading	Current aircraft heading	
position	Current aircraft position	position can be in the following forms, • Designator; • Latitude/Longitude; • Relative point; • NAVAID; or • Aerodrome.
time	Time when all data in this class is reported	

Class	Definition	Reference/Remark
ApacActualTrajectoryType	Class containing all trajectory elements of a flight	This class is to be included in extension field under Flight Type class.
Data Attribute	Definition	Reference/Remark
element	A list of trajectory elements	

Class	Definition	Reference/Remark
ApacActualTrajectoryElementType	Class containing composition of each trajectory element(s) specified in ApacTrajectoryType	
Data Attribute	Definition	Reference/Remark

level	An estimated flight level of the aircraft at this trajectory element	level can be in the following forms, • Flight level; or • Altitude.
point	A specified position of this trajectory element	point can be in the following forms, • Designator; • Latitude/Longitude; or • Relative point.
actualTimeOver	An actual time of the aircraft over routePoint	

Class	Definition	Reference/Remark
ApacRouteTrajectoryElementType	Class containing traffic synchronous information	
Data Attribute	Definition	Reference/Remark
targetTimeOver	A time, calculated and issued by an ATS unit, that an aircraft is requested to be over a fix, waypoint, or particular location	Use case: a time progressively calculated and issued by arrival management (AMAN) system

FIXM version 4.2 Core Data Attributes to Support Cross-Border ATFM Information Exchange

Data Attribute	FIXM version 4.2 Core
ETO (Estimated Time Over)	FlightType.routeTrajectoryGroup.filed.element.point4D.time = (ETO) FlightType.routeTrajectoryGroup.filed.element.elementStartPoint = (point at which ETO is specified)
ELDT (Estimated Landing Time)	FlightType.routeTrajectoryGroup.filed.element.point4D.time = (ELDT) FlightType.routeTrajectoryGroup.filed.element.point4D.pointProperty.propertyType = WHEELS_ON FlightType.routeTrajectoryGroup.filed.element.elementStartPoint.aerodromReferencePoint.locationIndicator = FlightType.arrival.destinationAerodrome.locationIndicator
CTOT (Calculated Take-Off Time)	FlightType.routeTrajectoryGroup.negotiating.element.constraint.time.timeSpecification.timeValue = (CTOT) FlightType.routeTrajectoryGroup.negotiating.element.point4D.pointProperty.propertyType = WHEELS_OFF FlightType.routeTrajectoryGroup.negotiating.element.elementStartPoint.aerodromReferencePoint.locationIndicator = FlightType.departure.aerodrome.locationIndicator
CTO (Calculated Time Over)	FlightType.routeTrajectoryGroup.negotiating.element.constraint.time.timeSpecification.timeValue = (CTO) FlightType.routeTrajectoryGroup.negotiating.element.elementStartPoint = (point at which CTO is specified)
CLDT (Calculated Landing Time)	FlightType.routeTrajectoryGroup.negotiating.element.constraint.time.timeSpecification.timeValue = (CLDT) FlightType.routeTrajectoryGroup.negotiating.element.point4D.pointProperty.propertyType = WHEELS_ON FlightType.routeTrajectoryGroup.negotiating.element.elementStartPoint.aerodromReferencePoint.locationIndicator = FlightType.arrival.destinationAerodrome.locationIndicator
EIBT (Estimated In-Block Time)	FlightType.routeTrajectoryGroup.filed.element.point4D.time = (EIBT) FlightType.routeTrajectoryGroup.filed.element.point4D.pointProperty.propertyType = END_STAY FlightType.routeTrajectoryGroup.filed.element.elementStartPoint.aerodromReferencePoint.locationIndicator = FlightType.arrival.destinationAerodrome.locationIndicator

Part of FIXM version 4.2 Core Sample Messages

Data Attribute	Part of FIXM version 4.2 Core Sample Messages
ETO (Estimated Time Over)	<pre> <fx:element seqNum="0"> <fx:elementStartPoint> <fb:designatedPoint> <fb:designator>KIGOB</fb:designator> </fb:designatedPoint> </fx:elementStartPoint> <fx:point4D> <fx:time> <fx:absoluteTime>2023-05- 10T01:11:00Z</fx:absoluteTime> </fx:time> </fx:point4D> <fx:routeDesignatorToNextElement> <fx:routeDesignator>Y11</fx:routeDesignator> </fx:routeDesignatorToNextElement> </fx:element> </pre>
ELDT (Estimated Landing Time)	<pre> <fx:element seqNum="5"> <fx:elementStartPoint> <fb:aerodromeReferencePoint> <fb:locationIndicator>WSSS</fb:locationIndicator> </fb:aerodromeReferencePoint> </fx:elementStartPoint> <fx:point4D> <fx:pointProperty> <fx:propertyType>WHEELS_ON</fx:propertyType> </fx:pointProperty> <fx:time> <fx:absoluteTime>2023-05- 10T02:54:00Z</fx:absoluteTime> </fx:time> </fx:point4D> </fx:element> </pre>

Data Attribute	Part of FIXM version 4.2 Core Sample Messages
CTOT (Calculated Take-Off Time)	<pre> <fx:element seqNum="0"> <fx:constraint> <fx:time> <fx:timeSpecification> <fb:timeValue>2023-05- 10T01:15:00Z</fb:timeValue> </fx:timeSpecification> </fx:time> </fx:constraint> <fx:elementStartPoint> <fb:aerodromeReferencePoint> <fb:locationIndicator>VTBS</fb:locationIndicator> </fb:aerodromeReferencePoint> </fx:elementStartPoint> <fx:point4D> <fx:pointProperty> <fx:propertyType>WHEELS_OFF</fx:propertyType> </fx:pointProperty> </fx:point4D> </fx:element> </pre>
CTO (Calculated Time Over)	<pre> <fx:element seqNum="1"> <fx:constraint> <fx:time> <fx:timeSpecification> </pre>

	<pre> <fb:timeValue>2023-05- 10T01:21:00Z</fb:timeValue> </fx:timeSpecification> </fx:time> </fx:constraint> <fx:elementStartPoint> <fb:designatedPoint> <fb:designator>KIGOB</fb:designator> </fb:designatedPoint> </fx:elementStartPoint> </fx:element> </pre>

Data Attribute	Part of FIXM version 4.2 Core Sample Messages
CLDT (Calculated Landing Time)	<pre> <fx:element seqNum="2"> <fx:constraint> <fx:time> <fx:timeSpecification> <fb:timeValue>2023-05- 10T03:04:00Z</fb:timeValue> </fx:timeSpecification> </fx:time> </fx:constraint> <fx:elementStartPoint> <fb:aerodromeReferencePoint> <fb:locationIndicator>WSSS</fb:locationIndicator> </fb:aerodromeReferencePoint> </fx:elementStartPoint> <fx:point4D> <fx:pointProperty> <fx:propertyType>WHEELS_ON</fx:propertyType> </fx:pointProperty> </fx:point4D> </fx:element> </pre>
EIBT (Estimated In-Block Time)	<pre> <fx:element seqNum="6"> <fx:elementStartPoint> <fb:aerodromeReferencePoint> <fb:locationIndicator>WSSS</fb:locationIndicator> </fb:aerodromeReferencePoint> </fx:elementStartPoint> <fx:point4D> <fx:pointProperty> <fx:propertyType>END_STAY</fx:propertyType> </fx:pointProperty> <fx:time> <fx:absoluteTime>2023-05- 10T03:09:00Z</fx:absoluteTime> </fx:time> </fx:point4D> </fx:element> </pre>

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version="4.2.0">
    <xs:annotation>
        <xs:documentation>The Apac package contains information used in Asia
Pacific region.</xs:documentation>
    </xs:annotation>
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    <xs:import namespace="http://www.fixm.aero/base/4.2"
schemaLocation="..\..\core\base\Base.xsd"/>
    <xs:import namespace="http://www.fixm.aero/base/4.2"
schemaLocation="..\..\core\base\Extension.xsd"/>
    <xs:import namespace="http://www.fixm.aero/flight/4.2"
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schemaLocation="..\..\core\base\Measures.xsd"/>
    <xs:import namespace="http://www.fixm.aero/base/4.2"
schemaLocation="..\..\core\base\RangesAndChoices.xsd"/>
    <xs:import namespace="http://www.fixm.aero/base/4.2"
schemaLocation="..\..\core\base\Types.xsd"/>

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        <xs:annotation>
            <xs:documentation>Class containing traffic synchronous
information</xs:documentation>
        </xs:annotation>
        <xs:complexContent>
            <xs:extension base="fb:RouteTrajectoryElementExtensionType">
                <xs:sequence>
                    <xs:element name="targetTimeOver"
type="fb:TimeType" minOccurs="0" maxOccurs="1" nillable="true">
                        <xs:annotation>
                            <xs:documentation>A time, calculated
and issued by an ATS unit, that an aircraft is requested to be over a fix, waypoint, or
particular location [Use case: a time calculated by arrival management (AMAN)
system]</xs:documentation>
                        </xs:annotation>
                    </xs:element>
                </xs:sequence>
            </xs:extension>
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    </xs:complexType>

    <xs:complexType name="ApacDepartureType">
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```

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        <xs:documentation>Class containing ATFM data related to departure
aerodrome. This class is to be included in extension field under DepartureType
class</xs:documentation>
    </xs:annotation>
    <xs:complexContent>
        <xs:extension base="fb:DepartureExtensionType">
            <xs:sequence>
                <xs:element name="actualOffBlockTime"
type="fb:TimeType" minOccurs="0" maxOccurs="1">
                    <xs:annotation>
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time value is not EIBT (Estimated In-Block Time) – The estimated time that an aircraft will
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March 2017)]</xs:documentation>
                        </xs:annotation>
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[level can be in the following forms, Flight level; or Altitude]</xs:documentation>
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Asia/Pacific Regional Aeronautical Radio Frequency Management Guidance Material

Edition 1.0

International Civil Aviation Organization

AMENDMENTS

Amendments are announced in the supplements to the *Publications Catalogue*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS, CORRIGENDA AND ADDENDA

[illegible]

TABLE OF CONTENTS

	<i>Page</i>
Chapter 1 INTRODUCTION	1-1
1.1 OBJECTIVE and SCOPE	1-1
Chapter 2 BACKGROUND.....	2-1
2.1 Institutional framework.....	2-1
2.2 Spectrum coordination and management	2-2
Chapter 3 AIR-GROUND COMMUNICATION FREQUENCY MANAGEMENT	3-1
3.1 HF Air-ground Communication Frequency bands	3-1
3.2 VHF Air-ground Communication Frequency bands	3-1
Chapter 4 RADIO NAVIGATION AID FREQUENCY MANAGEMENT	4-1
4.1 Non-Directional Radio Beacons (NDB)	4-1
4.2 Instrument Landing System (ILS).....	4-1
4.3 VHF Omnidirectional Range (VOR)	4-5
4.4 Ground Based Augmentation System (GBAS)	4-7
4.5 Distance Measuring Equipment (DME).....	4-11
4.6 Identifications of Radio Navigation Aids.....	4-13
Appendix A TEMPLATE FOR AN EXCEL OR WORD FILE THAT CAN BE USED FOR ELECTRONIC SUBMISSION OF ONE (OR MORE) NEW OR MODIFIED FREQUENCY ASSIGNMENTS FOR NAV SYSTEMS TO THE REGIONAL OFFICE.....	APP A-1
Appendix B PREFERRED FORMAT OF THE CHARACTERISTICS OF SUBMISSIONS.....	APP B-1
Appendix C REGIONAL 117.975-137MHz FREQUENCY ALLOTMENT PLAN	APP C-1
Appendix D GENERIC CALCULATION METHOD FOR GEOGRAPHICAL SEPARATION DISTANCES	APP D-1
Appendix E PAIRING OF ILS/VOR/DME CHANNELS.....	APP E-1

ABBREVIATIONS

AOC	Aeronautical operational control
AM(R)S	Aeronautical Mobile (Route) Service
ANSP	Air Navigation Service Provider
ARNS	Aeronautical Radionavigation Service
ATC	Air Traffic Control
CAA	Civil Aviation Authority/Administration
CNS	Communications, Navigation and Surveillance
DME	Distance Measuring Equipment
DOC	Designated Operational Coverage
EIRP or e.i.r.p	Equivalent Isotropically Radiated Power or Effective Isotropic Radiated Power
FSMP	Frequency Spectrum Management Panel (successor of ACP WG/F (frequency))
GBAS	Ground-Based Augmentation System
HF	High Frequency
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
MIFR	Master International Frequency Register (ITU)
NDB	Non-directional radio Beacon
PAR	Precision Approach Radar
RR	Radio Regulations (ITU)
SARPs	Standards and Recommended Practices
TIBA	Traffic Information Broadcasts by Aircraft
VDB	VHF Data Broadcast (used with GBAS)
VDL	VHF Digital Link
VHF	Very High Frequency
VOLMET	Meteorological Information for aircraft in flight
VOR	VHF Omnidirectional Radio Range

Chapter 1

INTRODUCTION

This guidance material has been developed under a recommendation from the fourth meeting of the Spectrum Review Working Group (SRWG/4) of APANPIRG which was held via video conferencing from 09 to 10 June 2020. It is for States/Administrations in the APAC region to implement the frequency assignments in a coordinated manner with ANSP, CAA and national frequency Authorities to satisfy future operational needs or the introduction of new technologies, with emphasis on communication and navigation systems. (SRWG-4 Final report)

1.1 OBJECTIVE and SCOPE

1.1.1 Aeronautical services are recognized internationally to be prime users of radio frequencies. [DOC9718, Vol 1,1.2] The civil aviation community must accordingly develop and present, as necessary, its agreed policies and its quantified and qualified statements of requirement for radio frequency spectrum to ensure the continuing availability of adequate radio spectrum and, ultimately, the ongoing viability of air navigation services throughout the world. [DOC9718, Vol 1,1.4]

1.1.2 For the APAC Region, the Secretariat is developing, with the support of ICAO contracting states, material to support frequency assignment planning in the region.

1.1.3 In accordance with above, the prime objectives of this document are:

- a) to provide background information on the international spectrum management institutional framework.
- b) to provide a convenient record for important frequency planning principles and coordination procedure.
- c) to provide frequency assignment planning criteria to secure that aeronautical radio communication and navigation systems are protected from harmful interference on a uniform basis.

1.1.4 This guidance material describes general references in aeronautical frequency management of APAC region, including the introduction and relationships between the main participants, overview of the framework and process of aeronautical spectrum management, etc.

1.1.5 This document is suitable for national authorities, telecommunication authorities (or telecommunication administrations), ATCs, aerodromes, and airlines which will management or use aeronautical frequencies.

1.1.6 This Guidance Material is not intended to and shall not replace the relevant requirements stipulated in Annex 10 and Doc 9718. In the event of any inconsistency or conflict between this document and Annex 10 and Doc 9718, Annex 10 and Doc 9718 shall take precedence.

Chapter 2

BACKGROUND

2.1 Institutional framework

2.1.1 ITU

2.1.1.1 The International Telecommunication Union (ITU) is the United Nations specialized agency for information and communication technologies (ICTs). To facilitate international connectivity in communications networks, ITU allocate global radio spectrum and satellite orbits, develop the technical standards that ensure networks and technologies seamlessly interconnect.

Note: Other specialized agencies, such as ICAO, would not be barred from any kind of work touching upon aeronautical telecommunications including standardization activities.

2.1.1.2 The legal framework of ITU comprises the basic instruments of the Union, which have treaty status and are binding on ITU Member States. These instruments are the Constitution and Convention of the International Telecommunication Union and the Administrative Regulations, which complement the Constitution and the Convention. The Radio Regulations (RR) form an integral part of the Administrative Regulations.

2.1.1.3 The RR include allocations, provisions on licensing, interference resolution, safety and distress procedures and other aspects. Within the RR, the finite useable radio spectrum, from approximately 8.3 kHz to 275 GHz, is allocated to user services in response to their recognized demands, and among three ITU world Regions in accordance with the major regional spectrum requirements for these services in the relevant region. [DOC9718, Vol 1,3.3] To enable new technologies and changes in spectrum usage, an ITU World Radiocommunication Conference (WRC) is held every 4 years where parts of the Radio Regulations are revised and updated.

2.1.1.4 Aviation services are recognized important users of radio spectrum to create safe and expeditious conditions to support air operations. The AM(R)S, the ARNS and their satellite service counterparts are important components in the mobile and radiodetermination families of users with (normally) exclusive allocations made on a worldwide basis to ensure global harmonization. The RR are used as the framework for the relevant ICAO Annexes and the Standards and Recommended Practices (SARPs) contained therein. [DOC9718, Vol 1, 3.5]

2.1.2 ICAO

2.1.2.1 Pursuant to the provisions in Art 37 of the Convention on International Civil Aviation, ICAO develops Standards and Recommended Practices (SARPs) for Communication, (radio) Navigation and Surveillance (CNS) systems. These standards include technical characteristics and protection requirements to secure interference free operation of these systems and are incorporated in Annex 10. [DOC 9718, V1, 5.1]

2.1.2.2 In order to provide for more detailed guidance material on the provisions in Annex 10 for CNS systems, ICAO has developed Doc 9718. Doc 9718 is (currently) published in two parts:

- Volume I which contains material relevant to the allocation and use of aeronautical frequency bands by the ITU.
- Volume II which contains material relevant to the frequency assignment planning for CNS systems.

2.1.2.3 ICAO is accorded observer status at relevant ITU WRCs and also participates at meetings of the ITU-R study groups, including the Conference Preparatory Meetings (CPMs) which prepare the technical and regulatory basis for WRCs. [DOC 9718, V1, 5.2] Within ICAO, the necessary activity to support these ITU-generated functions exists at two levels:

- a) At the worldwide level, through the work of the Air Navigation Commission, with the assistance of the FSMP (and communication divisional meetings or air navigation conferences, as required), to prepare the coordinated ICAO policies, spectrum estimates and technical inputs for ITU conferences and ITU-R study groups. The ICAO spectrum strategy, policy statements and the ICAO Position for WRCs are approved by the Council; and
- b) At the regional level, by the ICAO Regional Offices, through coordination of frequency assignment plans with states/administrations, using agreed ICAO planning criteria. This activity is supported by the Regional Planning and Implementation Groups (PIRGs).

2.1.2.4 At a Regional level, Air Navigation Plans have been developed. These ANPs contain, based on Regional Air Navigation Agreements, provisions that States have agreed to apply on the use of aeronautical radio communication, navigation and surveillance systems, including material relevant to frequency assignment planning.

2.1.3 National and regional authorities

2.1.3.1 Within ITU Member States, the telecommunication authorities / administrations normally control and operate the mechanism which develops the national proposals for amending the Radio Regulations for submission to the ITU WRCs. [Doc 9718 volume 1 3.4] The outcome of these discussions in the WRCs normally results in material being incorporated in the ITU Radio Regulations or in ITU-R Recommendations and subsequently being applied through national regulation by national telecommunication authorities. [DOC9718, Vol 1,5.2]

2.1.3.2 To develop and maintain the ICAO Spectrum Strategy and Policy on Radio Frequency Spectrum, a coordinated aeronautical position (the ICAO Position) and other materials must be established for every ITU WRC to support the update of the ITU Radio Regulations (RR). All ICAO Member States and relevant international organizations are encouraged to present proposals to develop the ICAO Position.

2.1.3.3 National and international (regional) preparatory committees function as the coordination medium to which the aeronautical requirements and proposals, either from ICAO coordinated or nationally derived, are presented by the national aviation authorities for consideration. [Modify from DOC9718, Vol 1, 3.4]

2.1.3.4 It is essential that aeronautical participation in these national and regional activities be ensured in order to support and defend aviation requirements. [DOC9718, Vol 1, 3.4]

2.1.4 Relationship between ITU RR and ICAO SARPS

2.1.4.1 The Radio Regulations have treaty status, and there is an inherent obligation on States to comply, unless an exception is stated and embodied in the Final Acts of the Conference which created the regulation. Aeronautical services are obliged to operate within the framework established by the Radio Regulations.

2.1.4.2 ICAO is recognized internationally as the competent international body to coordinate a worldwide policy for the operational use of the specified systems. Furthermore, the ICAO Annexes contain procedures for regular and emergency communications that are specifically developed for aviation purposes, taking account of the operational conditions. These procedures supplement the basic requirements of the Radio Regulations for procedures in aeronautical communications. [DOC9718, Vol 1,4.4.3]

2.1.4.3 The Radio Regulations and ICAO SARPs together thus form a complementary set of regulatory provisions without any overlap. The Radio Regulations must evolve within the general telecommunications environment with its many and diverse users of the radio frequency spectrum, while the ICAO SARPs respond to the operational safety aspects of air navigation and are developed and agreed by aviation within the ICAO organizational framework. [DOC9718, Vol 1,4.4.4]

2.2 Spectrum coordination and management

2.2.1 General

2.2.1.1 In using frequency bands for radio services, ITU Members States shall bear in mind that radio frequencies are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of Radio Regulations, Annex 10 to the ICAO Convention and national and regional planning. [RR 0.3]

2.2.1.2 Any new assignment or any change of frequency or other basic characteristic of an existing assignment shall be made in such a way as to avoid causing harmful interference to services rendered by stations using frequencies assigned in accordance with this guidance material. [RR 4.3]

2.2.1.3 Frequency assignment planning should ensure the availability and protection from harmful interference of the frequencies provided for distress and safety purposes. [RR 0.7]

2.2.2 Frequency coordination and registration [DOC9718, Vol 1,4.5]

2.2.2.1 The coordination and registration of frequency assignments is the prerogative of the ITU and must be performed in accordance with procedures laid down in the Radio Regulations. Frequencies are registered in the Master International Frequency Register (MIFR) maintained at ITU Headquarters in Geneva. However, Incorporation of aeronautical frequencies in the MIFR is not subject to a technical analysis of the assignment for protecting other assignments in the COM lists from harmful interference

2.2.2.2 In exclusive aeronautical bands, actual (day-to-day) coordination of frequency assignments is being undertaken by ICAO, through the ICAO Regional Offices. [DOC9718, Vol 1,4.5.2]. The Regional Office's frequency coordination role includes the coordination with the ICAO regional offices of regions that may be affected by the proposed frequency assignments, or, if bilateral coordination is required in the region(s), the State(s)/ Administration(s) that may be affected.

2.2.2.3 To support this coordination, the ICAO Regional Offices have developed the necessary procedures, including the relevant frequency assignment planning criteria. Coordination of frequency assignments is taking place (in most cases) in coordination with the national civil aviation authorities. [DOC9718, Vol 1, 4.5.2]

2.2.2.4 Although in some cases aeronautical frequency assignments, notably those in HF and LF/MF bands, are registered with the ITU by the countries operating these services, other frequency assignments, particularly those in bands above 100 MHz, tend to be recorded only in national registers or in the ICAO Regional Air Navigation Plans. Because of this, de facto, the ICAO frequency register within ICAO forms the basis for international coordination of frequency assignments. [DOC9718, Vol 1,4.5.3]

2.2.2.5 This does not dispense with the more general requirement for the coordination of a frequency assignment within the ITU and the registration of this frequency assignment in the MIFR, if international protection of that assignment is necessary.

2.2.2.6 Coordination and registration of frequency assignments in the HF bands (between 2850 kHz and 22000 kHz) is only taking place through the ITU. However, ICAO is considering developing, in parallel, a relevant ICAO list of HF frequency assignments. [DOC9718, Vol 1, 4.5.4]

2.2.2.7 Coordination and registration of frequency assignments for radar stations and on-board autonomous radio navigation systems is however NOT being coordinated through ICAO. [DOC9718, Vol 1, 4.5.5]

2.2.2.8 List of frequency bands coordinated by ICAO is given in Table 2.1.

Table 2.1 List of frequency bands

Symbols	Frequency range	Facility
LF/MF	190 – 495 kHz and 505 – 526.5 kHz	NDB and locator
VHF	108 – 117.975 MHz 117.975 – 137 MHz	ILS localizer (below 112 MHz), VOR and GBAS Air-ground communications (e.g., VDL Mode 4)
UHF	328.6 – 335.4 MHz 960 – 1215 MHz	ILS glide path DME/TACAN SSR

2.2.3 Procedure of Coordination for aeronautical frequency in APAC Region

2.2.3.1 The ICAO Third Asia/Pacific Regional Air Navigation (ASIA/PAC/3 RAN) Meeting in 1993 agreed that the ICAO APAC Regional Office would continue to maintain its frequency selection and coordination role, including the maintenance and promulgation of Frequency List Nos.1, 2 and 3 in a timely and periodic manner.

2.2.3.2 with the successful implementation of Frequency Finder, there is no more Frequency List No. 3 published by the ICAO APAC Regional Office after the 29th Edition in January 2016, and is replaced by the up-to-date database in Frequency Finder.

Note: Frequency Finder is the ICAO aeronautical radio frequency management tool for VHF COM and NAV frequency assignments.

2.2.3.3 The updated Frequency Lists of Nos. 1 and 2 are published on the APAC website under – CNS More Documents through secure portal of ICAO APAC website webpage, or can be downloaded from the ICAO database with Frequency Finder.

Note: ICAO APAC Office synchronized all registered assignments on Frequency List No.2 into Frequency Finder in 2022 and has been using Frequency Finder on frequency assignments for NAV systems.

2.2.3.4 Currently, States/Administrations can submit to the Regional Office their requests for new or modified frequency assignments in any format (e.g., letter, email). [SRWG/4 WP2 2.3]

- a) The administrative aspects of the frequency coordination can be improved by States/Administrations using Frequency Finder to generate electronic submissions for new or modified frequency assignments. This option permits States/Administrations to check a selected frequency to satisfy any operational need and to check the

compatibility of this (proposed) frequency with other frequency assignments in the Frequency List No.2 or No.3. It greatly facilitates the final coordination that is performed by the ICAO Regional Office. The electronic submission(s) as generated with Frequency Finder, in the format of an Excel file, can be sent to the ICAO Regional Office through email.

- b) The second option for States/Administrations to submit to the Regional Office requests for registering new or modified frequency assignments, also by electronic means, through a locally generated Excel or Word file that follows the template as in [Appendix A](#).
- c) The third option is for States/Administrations to submit to the Regional Office requests for new of modified frequency assignment by letter. The preferred format of the characteristics for these submissions is in [Appendix B](#).

2.2.3.5 The basic aeronautical coordination procedure is depicted as Figure 2-1.

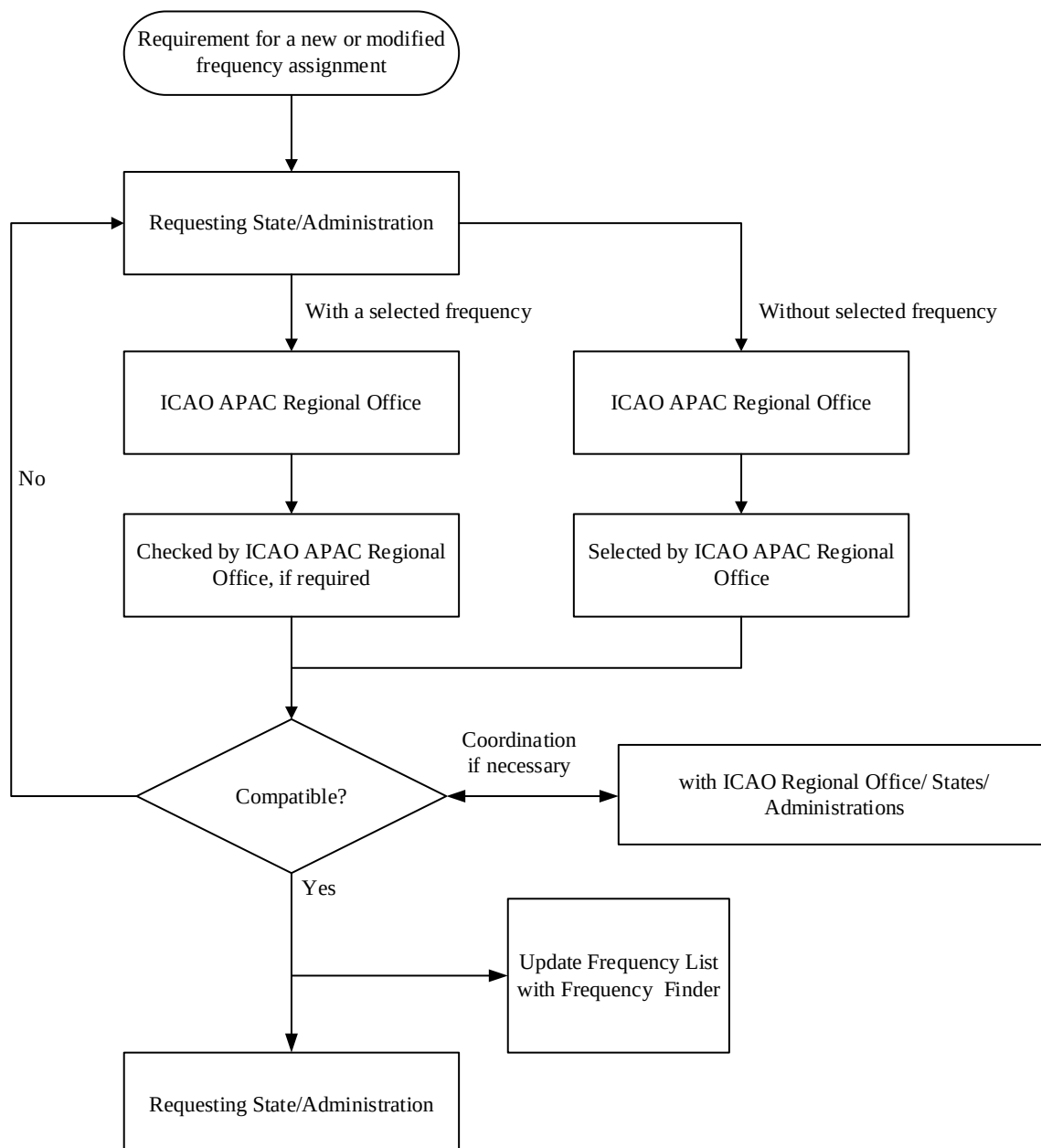


Figure 2-1 The basic aeronautical coordination procedure

Chapter 3

AIR-GROUND COMMUNICATION FREQUENCY MANAGEMENT

3.1 HF Air-ground Communication Frequency bands

3.1.1 HF bands (between 2850 kHz and 22 000 kHz) coordination is recommended to be carried out between States. Coordination and registration of HF frequencies is undertaken by the ITU, through the Radio Regulatory Authorities in each country. ICAO does not coordinate assignments for HF frequencies. [SRWG/1, WP04, 2.3] ICAO is considering developing, in parallel, a relevant ICAO list of HF frequency assignments. [DOC9718, Vol 1,4.5.4] Pre-coordination of HF frequencies could be arranged through the ICAO ASIA/PAC Office in Bangkok. However, the national radio regulator is required to develop a proposal for the registering required frequency assignments with the ITU. Such proposals should be based on the provisions of Appendix 27 to the ITU Radio Regulations, together with the information contained in the ITU International Frequency List (IFL) taking into consideration the protection requirements for HF as contained in Appendix 27. [SRWG/1, WP04]

3.1.2 Appendix 27 to the Radio Regulations (RR) contains the frequency allotment plan for the AM(R)S in the HF bands. This appendix contains the plan for HF frequency allotments to major world air route areas and to regional and domestic air route areas as well as VOLMET areas. It also includes worldwide frequency allotments, which are for the use of aircraft operating agencies for AOC, to be assigned in accordance with RR 27/217. [DOC9718, Vol 1, 4.2.6]

3.1.3 The technical characteristics for HF aviation equipment in Appendix 27 of the Radio Regulations, since they form part of the Radio Regulations, enjoy the same status as compulsory treaty obligations. [DOC9718, Vol 1,4.6]

3.2 VHF Air-ground Communication Frequency bands

3.2.1 The general allotment of frequency band 117.975 – 137.000 MHz shall be as shown in Table 3.1. Specific allotments to services are to be determined regionally. [ANN10, Vol 5, 4.1.1.1]

Table 3.1 Allotment table

Block allotment frequencies (MHz)	Worldwide utilization	Remarks
118.000 –121.450 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
121.500	Emergency frequency	See Annex 10, Volume V, 4.1.3.1. Channels 121.475 and 121.525 are not assignable.
121.550 –121.9917inclusive	International and National Aerodrome Surface Communications	Reserved for ground movement, pre-flight checking, air traffic services clearances, and associated operations.
122.000 –123.050 inclusive	National Aeronautical Mobile Services	Reserved for national allotments. National assignments are covered by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
123.100	Auxiliary frequency SAR	See Annex 10, Volume V, 4.1.3.4. Channels 123.075 and 123.125 are not assignable.
123.150 –123.425inclusive	National Aeronautical Mobile Services	Reserved for national allotments. National assignments are covered

		by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
123.450	Air-to-air communications	Reserved for air-to-air communication. Designated for use as provided for in Annex 10, Volume V, 4.1.3.2.
123.475-123.6917 inclusive	National Aeronautical Mobile Services	Reserved for national allotments. National assignments are covered by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
123.700 –129.6917 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
129.700 –130.8917 inclusive	National Aeronautical Mobile Services	Reserved for national allotments but may be used in whole or in part, subject to regional agreement. National assignments are covered by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
130.900 –136.875 inclusive	International and National Aeronautical Mobile Services	Specific international allotments will be determined in light of regional agreement. National assignments are covered by the provisions in Annex 10, Volume V, 4.1.4.8 and 4.1.4.9.
136.900 –136.975 inclusive	International and National Aeronautical Mobile Services	Reserved for VHF air-ground data link communications.

3.2.2 In accordance with the provisions of Annex 10, the emergency channel (121.500 MHz) shall be used only for genuine emergency purposes, and where a requirement is established for the use of a frequency auxiliary to 121.500 MHz, the frequency 123.100 MHz shall be used.

3.2.3 Common signalling channels for VDL [ANN10, Vol 5, 4.1.3.3]

3.2.3.1 The frequency 136.975 MHz is reserved on a worldwide basis to provide a common signalling channel (CSC) to the VHF digital link Mode 2 (VDL Mode 2).

3.2.3.2 In areas where VDL Mode 4 is implemented, the frequencies 136.925 MHz and 113.250 MHz shall be provided as common signalling channels (CSCs) to the VHF digital link Mode 4 (VDL Mode 4).

3.2.4 Frequencies should be assigned to all VHF Aeronautical Mobile Service (AMS) facilities in accordance with the principles laid out in Annex 10, Volume V and ICAO Handbook on Radio Frequency Spectrum Requirements for Civil Aviation (Doc 9718) Volumes I and II, and take into account:

- (a) agreed geographical separation criteria based on 25 kHz or 8.33 kHz interleaving between channels;
- (b) agreed geographical separation criteria for the implementation of VDL services;
- (c) the need for maximum economy in frequency demands and in radio spectrum utilization; and
- (d) a deployment of frequencies which ensures that international services are planned to be free of interference from other services using the same band. [APAC ANP Vol II,2.41]

3.2.5 The priority order to be followed in the assignment of frequencies to service is:

- (a) ATS channels serving international services (ACC, APP, TWR, FIS);
- (b) ATS channels serving national purposes;

- (c) channels serving international VOLMET services;
- (d) channels serving ATIS and PAR; and
- (e) channels used for other than ATS purposes. [APAC ANP Vol II, 2.42]

3.2.6 The criteria used for frequency assignment planning for VHF AMS facilities serving international requirements should, to the extent practicable, also be used to satisfy the need for national VHF AMS facilities. [APAC ANP Vol II, 2.43]

3.2.7 Special provisions should be made, by agreement between the States concerned, for the sharing and the application of reduced protection of non-ATS frequencies in the national sub-bands, so as to obtain a more economical use of the available frequency spectrum consistent with operational requirements. [APAC ANP Vol II, 2.44]

3.2.8 States should ensure that no air/ground frequency is utilized outside its designated operational coverage and that the stated operational requirements for coverage of a given frequency can be met for the transmission sites concerned, taking into account terrain configuration. [APAC ANP Vol II, 2.45]

3.2.9 APAC region has agreed to base frequency assignment planning on 25 kHz frequency separation. According to the conclusions of ASIA/PAC/3 RAN(DOC9614), APANPIRG/26, etc. The complete regional 117.975MHz-137MHz frequency band utilization plan is shown in [Appendix C](#), including the allotment of 12 unallocated frequencies for ACC services, which are 132.050 MHz, 132.075 MHz, 134.525 MHz, 134.550 MHz, 134.575 MHz, 135.825 MHz, 135.850 MHz, 135.875 MHz, 135.900 MHz, 135.925 MHz, 135.950 MHz, 135.975 MHz.

3.2.10 For co-frequency assignments, the minimum geographical separation between facilities shall be such that the DOC of each facility is separated by a distance not less than: [DOC9718, Vol 2, 2.3.1.2]

- (a) that required to provide a D/U ratio of 20 dB; or
- (b) the sum of the distance to the radio horizon of the DOC area of each facility.

Alternatively, in areas where the frequency congestion is severe, a protection ratio of 14 dB can be used on the basis of a regional air navigation agreement.

3.2.11 For adjacent frequency assignments, the minimum geographical separation between facilities shall be such that points at the edge of the designated operational coverage of each facility are separated by a distance sufficient to ensure operations free from harmful interference. [DOC9718, Vol 2, 2.3.1.3]

Note : The edge of the DOC is at the maximum range and maximum height.

3.2.12 Services and designated operational coverage (DOC) [DOC9718, Vol 2, 2.6]

3.2.12.1 Frequencies for aeronautical radio communication services are (normally) implemented to satisfy the operational need for specific services. These services, and their uniform DOC areas, are as in Table 3.2.

Table 3.2 Table of uniform designated operational coverage

Service	SYMBOL	Designated Operational Coverage (DOC)		Comments	Mode
		Range (NM)	Height (ft)		
Aerodrome					
Aerodrome control tower	TWR	25	4000	Height above ground	A/G
Aerodrome flight information service	AFIS	25	4000	Height above ground	A/G
Aerodrome surface communications	AS	Limits of aerodrome	Surface		A/G
Approach					
Precision approach radar	PAR	25	4000	Height above ground	A/G
Approach control service (lower)	APP-L	50	12000		A/G
Approach control service (intermediate)	APP-I	75	25000		A/G
Approach control service (upper)	APP-U	150	45000		A/G
En-Route					
Area control centre (lower)	ACC-L	Area	25000	Within specified area; max range 155 NM	A/G
Area control centre (intermediate)	ACC-I	Area	25000	Within specified area; max range 130 NM	A/G
Area control centre (upper)	ACC-U	Area	45000	Within specified area;	A/G

Service	SYMBOL	Designated Operational Coverage (DOC)		Comments	Mode
		Range (NM)	Height (ft)		
				max range 200 NM	
Flight information service (lower)	FIS-L	Area	25000	Within specified area; max range 155 NM	A/G
Flight information service or Flight information service (upper)	FIS or FIS-U	Area	45000	Within specified area; max range 200 NM	A/G
Meteorological information for aircraft in flight	VOLMET	200	45000	Maximum range 200 NM	BC
Other functions					
Automatic terminal information service	ATIS	200	45000		BC
Air-to-air	A/A	200	45000	Maximum range 200 NM	A/G
Air-to-ground	A/G	200	45000	Maximum range 200 NM	A/G
Aeronautical operational control	AOC	100	25000	Not protected; max. range 100 NM	A/G
Emergency	EM	N/A	N/A	No frequency coordination required	A/G
Search and rescue	SAR	N/A	N/A	No frequency coordination required	A/G
VHF En-Route General Purpose	GP	200	45000	Maximum range 200 NM	A/G

Note 1: Different DOC areas may be specified by States.

Note 2: DOC for AOC-only provided to enable compatibility assessment when frequencies for AOC are shared with air traffic control (ATC) services; different DOC may be specified.

Note 3: For area services, no frequency protection is provided outside the specified area.

Note 4: Unless specified by States, the DOC for A/A and A/G is assumed at 45 000 ft/200 NM.

Note 5: Mode: A/G: air-ground communications; BC: (ground) broadcast communications.

Note 6: No coordination of frequency assignment planning is necessary for the emergency frequency 121.500 MHz and the SAR frequency 123.100 MHz as these services are available globally at each station where this service is required.

3.2.12.2 Non-standard DOC (range and height) may be implemented as and when required. Reduced DOC, where operationally acceptable, may alleviate frequency congestion.

3.2.13 The criteria of Geographical separation

3.2.13.1 Applying the methodology as described in Handbook on Radio Frequency Spectrum Requirements for Civil Aviation (Doc 9718), Volume II, paragraph 2.8, separation distances between the edges of the designated coverage areas are shown in Table 3.3. [DOC9718, Vol 2, 2.8.2.1]

Table 3.3 Minimum geographical co-frequency separation distances between the edges of the DOC

		VICTIM											
	Service	TWR 25/4000	AFIS 25/4000	AS Surface	APP-U 150/450	APP- I 75/250	APP-L 50/120	ACC-U Area/450	ACC-L Area/250	FIS-U Area/450	FIS- L Area/250	VOLMET 260/450	ATIS 200/450
INTERFERE	TWR	156	156		338	273	212	338	273	338	273	338	338
	AFIS	156	156		338	273	212	338	273	338	273	338	338
	AS (Note 2)			25									
	APP-U	338	338		520	455	394	520	455	520	455	520	520
	APP-I	273	273		455	390	329	325	390	455	390	455	455
	APP-L	212	212		394	329	268	394	329	394	329	394	394
	ACC-U (Note 1)	338	338		520	455	394	520	455	520	455	520	520
	ACC-L (Note 1)	273	273		455	390	329	455	390	455	390	455	455
	FIS-U (Note 1)	338	338		520	455	394	520	455	520	455	520	520

		VICTIM											
	Service	TWR 25/4000	AFIS 25/4000	AS Surface	APP-U 150/450	APP- I 75/250	APP-L 50/120	ACC-U Area/450	ACC-L Area/250	FIS-U Area/450	FIS- L Area/250	VOLMET 260/450	ATIS 200/450
	FIS-L (Note 1)	273	273		455	390	329	455	390	455	390	455	455
	VOLMET	338	338		520	455	394	520	455	520	455	15	15
	ATIS	338	338		520	455	394	520	455	520	455	15	15

Note 1: All distances are in NM.

Note 2: Frequencies for aerodrome surface communications should be selected from the band 121.600 – 121.975 MHz. This band is reserved exclusively for aerodrome surface communications. No separation distances with other services are provided. Should it be necessary to share frequencies for AS with air/ground communication services, the minimum geographical separation distance can be calculated as shown in paragraph 2.7.2.1.1 and assuming a designated operational coverage for aerodrome surface communications of 5 NM/100 ft.

3.2.13.2 For stations operating on the first adjacent frequency with the same characteristics, a separation distance of 10 NM is to be maintained between the ground transmitter and the ground receiver. This is considered to be not a frequency assignment planning constraint but rather an implementation issue for States to consider when implementing or modifying frequency assignments. A practical measure may be to avoid assigning a first adjacent frequency to the same location. [DOC9718, Vol 2, 2.7.3.1.3]

3.2.13.3 The designated coverage for VDL Mode 2 and VDL Mode 4 facilities need to be separated from the designated coverage of a co-frequency VHF-COM voice (DSB-AM) system with at least the distance to the radio horizon of each service. [DOC9718, Vol 2, 2.9.1]

Note: This applies also to frequency assignments between VDL facilities.

3.2.13.4 Table 3.4 present the guard band (channels) between VDL operating on adjacent frequencies with other VDL or VHF COM voice (DSB-AM) systems. [DOC9718, Vol 2, 2.9.2]

Table 3.4 25 kHz guard band (channels) between DSB-AM, VDL mode 2 and VDL mode 4 (air-air)

		Interference source		
		DSB-AM	VDL 2	VDL 4
Victim	DSB-AM		1	2
	VDL 2	1	1	1
	VDL 4	2	1	1

Note: The numbers in Table are guard-bands (channels). The next frequency that can be used without frequency planning constrain is 1 channel higher (e.g., a desired DSB-AM station that is interfered by a VDL Mode 2 aircraft station requires one 25 kHz guard band. The next frequency, 50 kHz away, can be used in the same designated operational coverage without any frequency assignment planning constraint.

3.2.13.5 Table 3.5 present the guard band (channels) for VDL Mode 2, VDL Mode 4 and VHF COM voice (DSB-AM) systems, when operating with aircraft on the surface of an airport. [DOC9718, Vol 2, 2.9.3]

Table 3.5 25 kHz guard band (channels) between DSB-AM and VDL (modes 2 and 4) on the surface of an airport

		Interference source		
		DSB-AM	VDL 2	VDL 4
Victim	DSB-AM	-	4	4
	VDL 2	4	1	1
	VDL 4	4	1	1

Chapter 4

RADIO NAVIGATION AID FREQUENCY MANAGEMENT

4.1 Non-Directional Radio Beacons (NDB)

4.1.1 Frequency band – The radio frequencies assigned to NDBs shall be selected from those available in that portion of the spectrum between 190 kHz and 1 750 kHz. The coordination and registration of bands 190–495 kHz and 505– 526.5kHz take place in ICAO Regional office.

4.1.2 NDB frequency management should take into account the following:

- (a) the interference protection required at the edge of the rated coverage;
- (b) the application of the figures shown for typical ADF equipment;
- (c) the geographical spacings and the respective rated coverages;
- (d) the possibility of interference from spurious radiation generated by non-aeronautical sources (e.g., electric power services, power line communication systems, industrial radiation, etc.). [ANN10, Vol 5, 3.2.1]

4.1.3 The 1979 World Administrative Radio Conference adopted regulations concerning the assignment of frequencies for aeronautical radio beacons operating in the LF/MF frequency bands. A minimum protection ratio (wanted/unwanted signal ratio) of 15 dB is to be used as the basis for frequency assignment planning (RR Appendix 12).

4.1.4 The minimum value of field strength in the rated coverage of an NDB should be 70^omicrovolts per metre. In order to obtain a satisfactory service within the rated coverage of an NDB located in latitudes between 40°N and 50°S, a minimum value of field strength of 120 microvolts per metre would be required, except where practical experience in the operation of NDBs over several years has revealed that a minimum field strength of 70 microvolts per metre would be adequate to meet all the operational needs. In some specific areas, field strength values considerably in excess of 120 microvolts per metre would be required. Such areas are: Indonesia and Papua New Guinea, Myanmar, Malay Peninsula, Thailand, Lao People's Democratic Republic, Democratic Kampuchea, Viet Nam and Northern Australia [ANN10, Vol 1, 3.4.2.1and Attachment C, 6.1.1/ RR Appendix 12/ DOC 9614,ASIA/PAC/3]

Note: Based on the latest propagation and noise data available to the ITU, studies of minimum field strengths required at the boundary of the rated coverage was shown in 6.3 of Attachment C, Annex 10. Attention is called particularly to the assumptions made.

4.1.5 NDB Frequency assignments should be based on the criteria contained in Annex 10, Volume I, Chapter 3 paragraph 3.4.3 and the guidance material contained in Attachment C paragraph 6 of Annex 10, Volume I.

4.1.6 Where locators associated with ILS facilities serving opposite ends of a single runway are assigned a common frequency, provision shall be made to ensure that the facility not in operational use cannot radiate. [Annex 10 vol 1, Chapter3, paragraph 3.4.4.4]

4.1.7 To alleviate frequency congestion problems at locations where two separate ILS facilities serve opposite ends of a single runway, the assignment of a common frequency to both of the outer locators should be permitted, and the assignment of a common frequency to both of the inner locators should be permitted, provided that:

- (a) the operational circumstances permit;
- (b) each locator is assigned a different identification signal; and
- (c) arrangements are made whereby locators using the same frequency cannot radiate simultaneously. [ANN10, Vol 5, 3.2.2]

4.2 Instrument Landing System (ILS)

4.2.1 Frequency band and channel spacing

4.2.1.1 Frequency band –The Localizer is operating in the frequency band 108 – 112MHz. This band is also used for VOR and GBAS/VDB systems. Localizers cannot be assigned a frequency allotted for a VOR and vice versa. The Glide Path is operating in the frequency band 328.6–335.4MHz. The Localizer and Glide Path frequencies are paired as shown in Appendix E. [DOC9718, Vol 2, 3.3.1.1]

4.2.1.2 Channel spacing 100 kHz – The channel spacing for the Localizer is 100 kHz and for the Glide Path is 300 kHz. The Localizer operates on odd 100 kHz channels in the VHF band. [DOC9718, Vol2, 3.3.1.2]

4.2.1.3 Channel spacing 50 kHz – The use of 50 kHz channels for the localizer (and 150 kHz for the glide path) is permitted as stipulated in Annex 10, Volume V, paragraph 4.2.2.1. [DOC9718, Vol2, 3.3.1.3]

Note: Such use shall not cause harmful interference to ILS receivers not capable of tuning to these (50/150 kHz) channels and is subject to the condition that the operational service to international operators using airborne equipment designed for 100 kHz channel spacing (150 kHz for the Glide Path) is not derogated. [DOC9718 Vol2, 3.3.1.3]

4.2.1.4 When the ILS is associated with a DME, the DME channels must be selected as **Appendix E**. Further guidance on DME frequency assignment planning, including the ILS/DME channel pairing, is in section 4.5.

4.2.2 Designated Operational Coverage (DOC)

4.2.2.1 The horizontal Designated Operational Coverage of the Localizer and Glide Path is shown in Figure 4-1. The DOC can be extended (optional) with a range of 10 NM outside the clearance sector of the Localizer as promulgated by States/Administrations. [DOC9718, Vol 2, 3.2.1, 3.2.2.1]

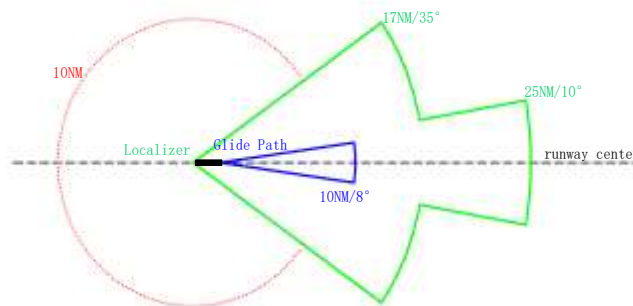


Figure 4-1. DOC of the ILS Localizer and Glide Path

4.2.2.2 The maximum protection height for the localizer DOC is 6250 ft and for the Glide Path 2500 ft. This height is relative to the elevation of the Localizer transmitter. [DOC9718, Vol 2, 3.2.2]

4.2.2.3 States/Administrations may modify the coverage to meet specific operational requirements. Unless a (modified) DOC is provided, the standard DOC as in paragraph 4.2.2.1 is used in the frequency assignment planning process. [DOC9718, Vol 2, 3.2.3]

4.2.2.4 When the ILS is associated with a DME, the DOC of the DME is typically the same as for the Localizer. However, States/Administrations may require the associated DME to provide coverage in a larger area. [DOC9718, Vol 2, 3.2.4]

Note: In practice, many frequency assignments for a DME, associated with an ILS, have a DOC of 10.000 ft/100 NM. Frequency assignment planning criteria for DME are in section 4.5.

4.2.3 [PFD limit] The minimum field strength for a Localizer is 40 $\mu\text{V/m}$ (or 32 dB $\mu\text{V/m}$ or - 116 dBW) throughout the DOC. For a Glide Path the minimum field strength is 400 $\mu\text{V/m}$ (or 52 dB $\mu\text{V/m}$ or - 106 dBW). [DOC 9718 Vol2, 3.2.4.1]

4.2.4 ILS serving both ends of the same runway. [DOC9718, Vol 2, 3.2.7]

To alleviate frequency congestion problems at locations where two separate ILS facilities serve opposite ends of the same runway or different runways at the same airport, the assignment of identical ILS localizer and glide path paired frequencies should be permitted provided that:

- a) the operational circumstances permit;

- b) each localizer is assigned a different identification signal; and
- c) arrangements are made whereby the localizer and glide path not in operational use cannot radiate.

4.2.5 [Facility Code] Information on the planning of identifications can be found in section 4.6.

4.2.6 A compatibility assessment for potential interference that can be caused by FM broadcasting stations operating in the frequency band 87 – 108 MHz is necessary before a Localizer frequency can be put into operational use. The FM immunity performance requirements for Localizer receivers are contained in Annex 10, Volume I, paragraph 3.1.4. Additional information on the process to assess compatibility with FM broadcast stations is in Recommendation ITU-R SM.1009. [DOC9718, Vol 2, 3.6]

4.2.7 Frequency Assignment Planning Principles

4.2.7.1 When the main direction of radiation of the ILS system is not known, for frequency assignment planning purposes, the coverage is assumed to be omnidirectional. The localizer coverage is originated from the location of the Localizer; the Glide Path coverage is originated from the location of the Glide Path. [DOC9718, Vol 2, 3.2.5]

4.2.7.2 The criteria must be applied in respect of each localizer installation, in the sense that while of two localizers, the first may not cause interference to the use of the second, nevertheless the second may cause interference to the use of the first. [ANN 10, ATT C, 2.6.1]

4.2.7.3 The DOC for the Localizer is much larger than that for the Glide Path. When a localizer frequency has been assigned, the associated Glide Path frequency is automatically protected from harmful interference from other co-channel ILS facilities. However, when non-co-channel Localizer frequency has been assigned, a separate adjacent channel compatibility assessment is necessary for the Glide Path frequency with regard to other nearby ILS facilities operating on adjacent Glide Path frequencies. Therefore, the frequency assignment planning for Localizer and Glide Path has to be performed separately. [DOC9718, Vol 2, 3.3.1.5]

4.2.7.4 In so far as the wanted and unwanted carriers may produce a heterodyne note, the protection ratio ensures that the instrumentation is not affected. However, in cases where a voice facility is used, the heterodyne note may interfere with this facility. [DOC9718, Vol 2, 3.2.6]

4.2.8 Required Distance Separations of ILS/ILS Facilities

4.2.8.1 The minimum required separation distances between the desired ILS system and potentially interfering ILS systems are based on the assumption that protection against interference is afforded to the desired signal from the undesired signal is 20 dB. This corresponds to a disturbance of not more than 15 microamperes at the limit of the service distance of the ILS. [DOC9718, Vol 2, 3.4.1]

4.2.8.2 The minimum D/U ratios requirements within the DOC and different frequency separation to protect different receivers of Localizer / Glide Path can be referred to Annex 10, Volume I, Attachment C 2.6.2.1, 2.6.2.2.

4.2.8.3 Table 4.1 provides the minimum geographical separation distances (D) between the edge of coverage of a desired ILS facility and the location of an undesired ILS facility, established using the method in **Appendix D**.

Table 4.1 Separation distances between the edge of coverage of a desired ILS and an undesired ILS

Undesired Facility:					
	Δf :	Distance for 100 kHz receiver (desired facility)	D/U	Distance for 50 kHz receiver (desired facility)	D/U
Localizer (EIRP= 30 dBW)	0 kHz	268 NM	36 dB	268 NM	36 dB
	0 kHz	135 NM	20 dB	135 NM	20 dB
	50 kHz	94 NM	-7 dB	36 NM	-34 dB
	100 kHz	n/a	n/a	n/a	n/a
	150 kHz	9 NM	-50 dB	9 NM	-50 dB
Glide Path (e.i.r.p. = 20 dBW)	Δf :	300 kHz receiver	D/U	150 kHz receiver	D/U
	0 kHz	88 NM	36 dB	74 NM	36 dB
	0 kHz	71 NM	20 dB	58 NM	20 dB
	150 kHz	36 NM	-0 dB	11 NM	-20 dB
	300 kHz	11 NM	-20 dB	1 NM	-40 dB
	450 kHz	1 NM	-40	-	-

4.2.8.4 In Regions where both 100 kHz and 50 kHz Localizer channels are being used (300 kHz and 150 kHz channels for the Glide Path), the protection of the Localizer is based on receivers designed for 100 kHz channel spacing.

4.2.9 Geographical separation distances between (desired) Localizer and (undesired) adjacent frequency VOR facilities is as Table 4.2.

Table 4.2 Geographical separation distances between (desired) Localizer and (undesired) VOR

VOR Tx (dBW)	ΔF (kHz)	D/U(dB)	D (NM)	Remarks
17	50	-7	72	Undesired VOR; 100 kHz receiver;
17	50	-34	15	Undesired VOR; 50 kHz receiver;
17	100	-46	5	Undesired VOR; 50/100 kHz receiver;
17	150	-50	3	Undesired VOR; 50/100 kHz receiver;
20	50	-7	80	Undesired VOR; 100 kHz receiver;
20	50	-34	19	Undesired VOR; 50 kHz receiver;
20	100	-46	7	Undesired VOR; 50/100 kHz receiver;
20	150	-50	4	Undesired VOR; 50/100 kHz receiver;
30	50	-7	107	Undesired VOR; 100 kHz receiver;
30	50	-34	36	Undesired VOR; 50 kHz receiver;
30	100	-46	16	Undesired VOR; 50/100 kHz receiver;
30	150	-50	13	Undesired VOR; 50/100 kHz receiver;

Note: ITU-R aeronautical propagation curve for Localizer: 108 MHz, $h_1 = 20$ ft, $h_2 = 6250$ ft; 5% of the time.

4.2.10 Geographical separation distance between (desired) Localizer and the location of an (undesired) GBAS/VDB as Table 4.3.

Table 4.3 Geographical separation distances between a desired Localizer and an undesired GBAS/VDB

GBAS/VDB Tx (dBW)	ΔF (kHz)	D/U(dB)	D (NM)	Remarks
17	0	26	187	
17	25	0	108	
17	50	-34	20	
17	75	-46	5	
17	100	-65	0	Planning freedom

Note: ITU-R aeronautical propagation curve for Localizer: 108 MHz, $h_1 = 45$ ft, $h_2 = 6250$ ft; 5% of the time.

4.2.11 Practical experience in the operation of ILSs over several years has revealed that the minimum required separation distances of Annex 10, Volume I, Table C-3 can protect against interference to the desired signal. Required Localizer and Glide Path separation distances is shown in Table 4.4.

Table 4.4 Required distance separations

	Frequency separation	Minimum separation between second facility and the protection point of the first facility km (NM)	
		List A	List B
Localizer	Co-channel	148(80)	148(80)
	50kHz	37(20)	9(5)
	100kHz	9(5)	0
	150kHz	0	0
	200kHz	0	0
Glide path	Co-channel	93(50)	93(50)
	150kHz	20(11)	2(1)
	300kHz	2(1)	0
	450kHz	0	0
	600kHz	0	0
List A refers to the use of localizer receivers designed for 100 kHz channel spacing coupled with glide path receivers designed for 300 kHz channel spacing.			

List B refers to the use of localizer receivers designed for 50 kHz channel spacing coupled with glide path receivers designed for 150 kHz channel spacing.

Note 1. The above figures are based on the assumption of protection points for the localizer at 46 km (25 NM) distance and 1900 m (6250 ft) height and for the ILS glide path at 18.5 km (10 NM) distance and 760 m (2500 ft) height.

Note 2. States, in applying the separations shown in the table, have to recognize the necessity to site the ILS and VOR facilities in a manner which will preclude the possibility of airborne receiver error due to overloading by high unwanted signal levels when the aircraft is in the initial and final approach phases.

Note 3. States, in applying the separations shown in the table, have to recognize the necessity to site the ILS glide path facilities in a manner which will preclude the possibility of erroneous glide path indications due to reception of adjacent channel signals when the desired signal ceases to radiate for any reason while the aircraft is in the final approach phase.

Note: The application of the figures given in Table 4.4 will only be correct within the limitations set by the assumptions. If more precise determination of separation distances is required in areas of frequency congestion, this may be determined for each facility from appropriate propagation curves, taking into account the particular directivity factors, radiated power characteristics and the operational requirements as to coverage. Where reduced separation distances are determined by taking into account directivity, etc., flight measurements at the ILS protection point and at all points on the approach path should be made wherever possible to ensure that a protection ratio of at least 20 dB is achieved in practice. [Annex 10, ATT C 2.6.7]

4.3 VHF Omnidirectional Range (VOR)

4.3.1 Frequency band and channel spacing

4.3.1.1 VOR is operating in the frequency band 108–117.975MHz. Within band 108–111.975MHz, frequencies ending in either even tenths or even tenths plus a twentieth of a megahertz are used only by VOR that should no harmful adjacent channel interference to ILS. [DOC9718, Vol 2, 4.3.1.1 / ANN10, Vol 5, 4.2.1]

4.3.1.2 The channel spacing is 100 kHz. The use of 50 kHz VOR channels is permitted as stipulated in Annex 10, Volume V, paragraph 4.2.3.1.

Note: The use of 50 kHz VOR channels shall not cause harmful interference to VOR receivers not capable of tuning to these channels and the operational service to international operators using airborne 100 kHz equipment is not derogated. [DOC9718, Vol 2, 4.3.1.2]

4.3.1.3 In aera where VDL Mode 4 is implemented, the frequency 113.250 is reserved as common signalling channel for VDL Mode 4 (ANN10, Vol 5, 4.1.3.3.2).

4.3.1.4 VOR facilities are often associated with DME facilities. The associated DME channels shall be selected in Appendix E. Further guidance on DME frequency assignment planning, including the VOR/DME channel pairing, is in section 4.5.

Note: A separate compatibility assessment for the DME facilities associated with a VOR facility is required in all cases.

4.3.2 [DOC] The designated operational coverage (DOC) of the VOR is determined through the operational requirement as promulgated by States/Administrations. In many cases the DOC is circular and can typically vary from 25 NM to approximately 200 NM and the protected altitude up to between 10 000 feet and 60 000 feet. Protection from harmful interference is only provided within the DOC. [DOC9718, Vol2, 4.2.1]

Note: When the VOR is associated with a DME, the DOC of the DME is typically the same as for the VOR.

4.3.3 [PFD limit] The field strength or power density in space of VOR signals required should be 90 $\mu\text{V/m}$ (39 dB $\mu\text{V/m}$) or 107 dBW/m² (or - 110 dBW at 118 MHz) throughout the DOC. [ANN10, Vol 1, 3.3.4.2 / DOC9718 Vol 2, 4.2.2.1]

4.3.4 [With FM] A compatibility assessment for potential interference that can be caused by FM broadcasting stations operating in the frequency band 87 – 108 MHz is necessary. The FM immunity performance requirements for VOR receivers are contained in Annex 10, Volume I, paragraph 3.3.8. Additional information on the process to assess compatibility with FM broadcast stations is in Recommendation ITU-R SM.1009.

4.3.5 [Facility Code] Information on the planning of identifications can be found in section 4.6.

4.3.6 Protection criteria for a desired VOR and an undesired VOR or Localizer or GBAS/VDB

4.3.6.1 Localizer and VOR facilities cannot operate on the same frequency. Adjacent channel compatibility with an (undesired) Localizer is assessed in the same way as adjacent channel interference from a VOR assessed. [DOC9718, Vol 2, 4.3.4.2]

4.3.6.2 The protection of VOR facilities operating on the same frequency is based on a desired to undesired (D/U) signal ratio of 20dB. This corresponds to a bearing error of less than 1 degree due to unwanted signals. [DOC9718, Vol 2, 4.4.1]

4.3.6.3 Protection requirement for a desired VOR and undesired localizer or VOR facility is contained in Annex 10, Volume I, Attachment C, paragraph 3.6.4. and DOC 9718, Volume II, paragraph 3.4.

4.3.6.4 Protection criteria for a desired VOR and an undesired GBAS/VDB is contained in Annex 10, Volume I, Attachment D, paragraph 7.2.1.1, and DOC 9718, Volume II, paragraph 3.5.

4.3.6.5 Where both 100 kHz and 50 kHz VOR channels are being used, the protection of the VOR is based on receivers designed for 100 kHz channel spacing.

4.3.7 Sectorized coverage

4.3.7.1 Application of the calculation methods described above may produce incorrect results if sectorization (key-holing) is used. Figure 4-2 can be used to explain the problem:

4.3.7.2 Consider A to be the desired VOR facility and B the undesired one. The “Critical Point” is most exposed to interference from facility B because it is the point of the DOC of facility A which is nearest to transmitter B.

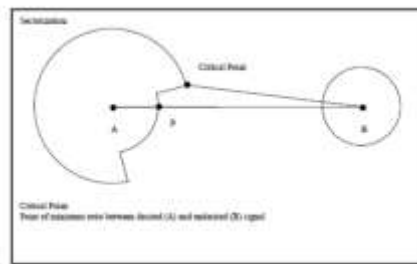


Figure 4-2 Geometry for determining the test points

4.3.8 Table 4.5 to Table 4.7 present the co- and adjacent frequency separation distance between the edge of the DOC of the (desired) VOR and the location of the (undesired) VOR or ILS-Localizer.

Table 4.5 Minimum separation distances between desired VOR and undesired VOR or LOC

ΔF (kHz)	D/U (dB)	Tx = 17 dBW		Tx = 20 dBW		Tx=30 dBW		Remarks
		L (dB)	D (NM)	L (dB)	D (NM)	L (dB)	D (NM)	
0	20	147	268	150	271	160	284	Desired VOR at 45000 ft 50/100 kHz receiver
50	-7	120	134	123	174	133	231	100 kHz receiver
50	-34	93	5	96	11	106	43	50 kHz receiver
100	-46	81	<0.5	84	<0.5	94	7	50/100 kHz receiver
150	-50	77	<0.5	80	<0.5	90	<0.5	50/100 kHz receiver

Table 4.6 Minimum separation distances between desired VOR and undesired VOR or LOC

ΔF (kHz)	D/U (dB)	Tx = 17 dBW		Tx = 20 dBW		Tx=30 dBW		Remarks
		L (dB)	D (NM)	L (dB)	D (NM)	L (dB)	D (NM)	
0	20	147	208	150	212	160	225	Desired VOR at 25000 ft 50/100 kHz receiver
50	-7	120	115	123	131	133	175	100 kHz receiver
50	-34	93	9	96	13	106	42	50 kHz receiver
100	-46	81	<0.5	84	<0.5	94	10	50/100 kHz receiver
150	-50	77	<0.5	80	<0.5	90	5	50/100 kHz receiver

Table 4.7 Minimum separation distances between desired VOR and undesired VOR or LOC

ΔF (kHz)	D/U (dB)	Tx = 17 dBW		Tx = 20 dBW		Tx=30 dBW		Remarks
		L (dB)	D (NM)	L (dB)	D (NM)	L (dB)	D (NM)	Desired VOR at 10000 ft
0	20	147	143	150	147	160	161	50/100 kHz receiver
50	-7	120	71	123	82	133	115	100 kHz receiver
50	-34	93	10	96	14	106	29	50 kHz receiver
100	-46	81	1	84	3	94	11	50/100 kHz receiver
150	-50	77	<0.5	80	1	90	7	50/100 kHz receiver

Note1: The separation distances are between the edge of coverage for a desired VOR and the location of an undesired VOR (or Localizer) facility. The EIRP of the undesired VOR (or Localizer) is as specified in column "Tx".

Note2: ITU-R aeronautical propagation curve for 108 MHz and 5% of the time. The antenna height of the desired aircraft receiver is indicated in the "Remarks" column, and the antenna height of undesired Localizer is 6 ft, undesired VOR is 20 ft.

4.3.9 Table 4.8 presents the co- and adjacent frequency separation distance between the edge of the DOC of the (desired) VOR and the location of the (undesired) GBAS/VDB station.

Table 4.8 Distance between the edge of the DOC of the desired VOR (50 kHz receiver) from GBAS/VDB

VOR Height (ft)	Co-frequency D/U = 26 dB L = 153 dB	1st adj freq. (+/-25 kHz) D/U = 0 dB L = 126 dB	2nd adj freq. (+/- 50 kHz) D/U = - 34 dB L = 92 dB	3rd adj freq. (+/-75 kHz) D/U = -46 dB L = 87 dB	4th adj freq. (+/- 100 kHz) D/U = -65 dB L = 61 dB
5 000	127 NM	80 NM	9 NM	5 NM	Frequency assignment planning freedom
10 000	161 NM	111 NM	8 NM	5 NM	
15 000	186 NM	135 NM	8 NM	4 NM	
20 000	206 NM	155 NM	8 NM	3 NM	
25 000	225 NM	172 NM	8 NM	2 NM	
30 000	242 NM	189 NM	7 NM	Frequency assignment planning freedom	
35 000	237 NM	203 NM	6 NM		
40 000	271 NM	217 NM	5 NM		
45 000	284 NM	228 NM	3 NM		
50 000	297 NM	242 NM	Planning freedom		
60 000	320 NM	264 NM			

Note 1: With minimum separation distances less than 0.5 NM frequency assignment planning freedom is assumed.

Note 2: Separation distances ≤ 5 NM may be considered as operational insignificant.

Note3: ITU-R aeronautical propagation curve for 108 MHz and 5% of the time. The antenna height of undesired GBAS/VDB is 45 ft.

4.4 Ground Based Augmentation System (GBAS)

4.4.1 [Frequency band and channel spacing] The GNSS ground-based augmentation system (GBAS) VHF data broadcast (VDB) frequency band is 108 to 117.975MHz. The lowest assignable frequency is 108.025 MHz and the highest assignable frequency is 117.950 MHz, the channel spacing is 25 kHz.

4.4.2 Designated Operational Coverage (DOC)

4.4.2.1 The DOC of the GBAS/VDB to provide the approach service is as shown in Figure 4-3.

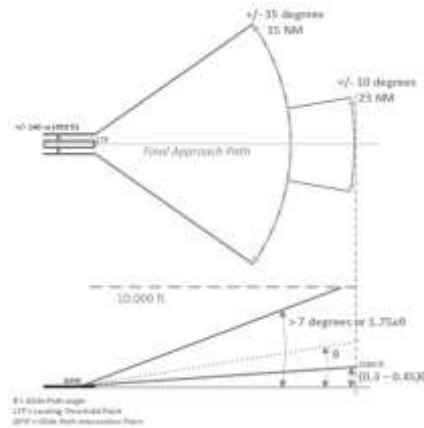


Figure 4-3 Minimum required DOC of GBAS

4.4.2.2 Typically, the DOC for GBAS/VDB facilities is referenced to the location and the elevation of the threshold of the runway. It is recommended to use an omnidirectional coverage that extends to 23 NM from the runway threshold and up to a level of 10,000 ft above runway threshold. [DOC9718, Vol 2, 6.2]

4.4.2.3 The vertical coverage is limited by a plane that extends from the glide path interception point with an angle of 0.3 times the Glide Path angle. The upper limit of coverage is 10000 ft that follows the Earth curvature. [DOC9718, Vol 2, 6.2]

4.4.2.4 When GBAS supports multiple approaches, use of a single omnidirectional VDB may be considered, if geographically feasible. In this case, frequency coordination should include all GBAS coverage areas. [DOC9718, Vol 2, 6.2]

4.4.2.5 Figure 4-3 presents the minimum approach DOC, States/Administrations may specify different (larger) DOC areas. More information on establishing the DOC is in Annex 10, Volume I, Attachment D, paragraph 7.3. [DOC9718, Vol 2, 6.2]

4.4.3 GBAS/VDB positioning service ERIP

4.4.3.1 The ERIP for the GBAS/VDB when providing the approach service is typically 17dBW (50 W) to provide service down to about 2 000 ft at the lower edge of the DOC. [DOC9718, Vol 2, 6.2.4.1]

4.4.3.2 The EIRP for the GBAS/VDB when providing the positioning service is in Table 4.9. [DOC9718, Vol 2, 6.2.4.2]

Table 4.9 Typical EIRP for GBAS/VDB positioning service

Range (NM)	EIRP (dBW)	EIRP (W)
50	14	25
100	20	100
150	23	200
200	26	400

Note: The EIRP of a GBAS/VDB system shall be provided as Peak Envelope Power. Since MOPS specify the output power to be measured as mean power over a bit-sequence in the preamble, care must be taken that the PEP is used for calculation. [EUR 011, 4.1.10]

4.4.4 [PFD limit] For frequency assignment planning purposes, it is assumed the field strength of the desired corresponds to the minimum field strength, as defined in Annex10, Volume I, throughout the designated operational coverage. The minimum field strength is 215 $\mu\text{V/m}$ (-99dBW/m²) which is equivalent to a power level at the aircraft antenna output of -102dBW with an ideal isotropic antenna (for the horizontal component of the GBAS/VDB signal). The maximum field strength is (SIS max) 0.879 V/m (-27dBW/m² or -29dBW). [DOC9718, Vol 2, 6.3.4]

4.4.5 For use in civil aviation, the GBAS signal is horizontally polarized. The value for cross polarization isolation between horizontal and vertical polarization assumed to be 10 dB [ANN10, Vol 1, Attachment D, 7.2.4).

4.4.6 [With FM] The risk of interference from FM broadcasting stations in the band 87 – 108 MHz caused by unwanted emissions into the aeronautical band or generated in the airborne receiver should be taken into account. The relevant Recommendation for GBAS is ITU-R SM.1841. [EUR 011, 4.1.4]

4.4.7 [Facility code] Information on the planning of identifications can be found in section 4.6.

4.4.8 Besides the frequency, co-ordination must also take into account reference path data selectors (RPDS) and reference station data selectors (RSDS) and time slots. More information on the use and coordination of RPDSs and RSDSs is in Annex 10, Volume I, Appendix B. [EUR 011, 4.1.6 / DOC9718, Vol 2, 6.5]

4.4.9 Protection requirements

4.4.9.1 Protection requirements for GBAS/VDB receivers.

The GBAS/VDB receiver shall be capable to achieve a message failure rate of not more than one failed message per 1000 data messages. The D/U ratios in Table 4.10 will meet this requirement.

Table 4.10 Co- and adjacent channel protection requirements for GBAS/VDB receivers

Frequency offset	VDB/VDB	VDB/VOR	VDB/ILS	VDB/VHF-COM
Co-frequency	26 dB	26 dB	26 dB	n/a
+/- 25 kHz	-18 dB	0 dB	0 dB	n/a
+/- 50 kHz	-43 dB	-34 dB	-34 dB	-32 dB
+/- 58.33 kHz	n/a	n/a	n/a	-37 dB
+/- 66.66 kHz	n/a	n/a	n/a	-41 dB
+/- 75 kHz – +/- 975 kHz	-46 dB	-46 dB	-46 dB	-44 dB
+/- 83.33 kHz	n/a	n/a	n/a	-47 dB
+/- 91.66 kHz	n/a	n/a	n/a	-49 dB
+/- 100 kHz	-46 dB	-46 dB	-46 dB	
≥ 1000 kHz	-46 dB	-60 dB	-60 dB	

4.4.9.2 Airborne Contribution Factor

- With the view to protect the desired VDB signals in space, an airborne contribution factor has been added. This airborne contribution factor compensates for antenna gain variations in the horizontal plane (between the directions of the desired versus the undesired transmitter) and on-board transmission line loss variation (between the frequency of the desired and the undesired signal). The airborne contribution factor can be calculated with $15 + \text{Min}(6, 6 \times \text{Frequency Offset (in kHz)} / 1000)$ with a maximum frequency offset of 1000 kHz.
- Table 4.11 contains the protection ratios that are to be observed in frequency assignment planning to protect a desired GBAS/VDB from interference that can be caused by an undesired GBAS/VDB, VOR or ILS or VHF COM facility.

Table 4.11 Co- and adjacent channel protection requirements for GBAS/VDB; signal-in-space

Frequency offset	VDB/VDB	VDB/VOR	VDB/ILS	VDB/VHF-COM
Co-frequency	41 dB	41 dB	41 dB	n/a
+/- 25 kHz	-3 dB	15 dB	15 dB	n/a
+/- 50 kHz	-27 dB	-18 dB	-18 dB	
+/- 58.33 kHz	n/a	n/a	n/a	
+/- 66.66 kHz	n/a	n/a	n/a	
+/- 75 kHz	-30 dB	-30 dB	-30 dB	
+/- 83.33 kHz	n/a	n/a	n/a	
+/- 91.66 kHz	n/a	n/a	n/a	
+/- 100 kHz				
+/- 975 kHz	-25 dB	-25 dB	--25 dB	
≥ 1000 kHz	-25 dB	-39 dB	-39 dB	

4.4.10 The separation distances between desired and undesired GBAS stations in Table 4.12 were calculated for desired GBAS facilities providing approach services.

Table 4.12 Minimum separation distances between desired and undesired GBAS stations

Frequency offset	D/U (dB)	L (dB)	Distance from DOC of desired station to undesired station	D/U (dB)	L (dB)	Distance from DOC of desired station to undesired station
0 (Co- channel)	41	160	213 NM	26	145	149 NM
25 kHz	-3	116	81 NM	-18	101	24 NM

50 kHz	-27	92	9 NM	-43	76	0
75 kHz – 975 kHz	-30 to -25	89 to 94	6 to 11 NM	-46	73	0
≥ 1000 kHz	-25	94	11 NM	-46	73	0

4.4.11 The calculation of the minimum separation distances between the edge of coverage (DOC) of a desired GBAS VDB facility and the location of an undesired VOR or Localizer in Table 4.13 and Table 4.14.

Table 4.13 Minimum separation distances between the DOC of the desired GBAS and the location of the undesired VOR or localizer

D/U (dB)	L(dB) 5%	VOR (17dBW) Distance (NM)	Localizer (17dBW) Distance (NM)	L(dB) 5%	VOR (27dBW) Distance (NM)	L(dB) 5%	VOR (30 dBW) Distance (NM)
26 ($\Delta f = 0$)	145	140	125	155	154	158	158
0 ($\Delta f = 25$)	119	68	38	129	101	132	111
-34 ($\Delta f = 50$)	85	4	4	95	12	98	17
-46 ($\Delta f = 75$)	73	0	0	83	3	86	4
-46 ($\Delta f = 100$)	73	0	0	83	3	86	4
-46 ($\Delta f = 975$)	73	0	0	83	3	86	4
-60 ($\Delta f \geq 1000$)	59	0	0	69	0	72	0

Table 4.14 Minimum separation distances between the DOC of the desired GBAS and the location of the undesired VOR or localizer, consider Airborne Contribution Factor

D/U (dB)	L(dB) 5%	VOR (17dBW) Distance (NM)	Localizer (17dBW) Distance (NM)	L(dB) 5%	VOR (27dBW) Distance (NM)	L(dB) 5%	VOR (30 dBW) Distance (NM)
41 ($\Delta f = 0$)	160	160	146	170	243	173	260
15 ($\Delta f = 25$)	134	118	85	144	138	147	143
-18 ($\Delta f = 50$)	101	21	14	111	43	114	51
-30 ($\Delta f = 75$)	89	6	6	99	18	102	23
-30 ($\Delta f = 100$)	89	6	6	99	18	102	23
-25 ($\Delta f = 975$)	94	11	8	104	26	107	31
-39 ($\Delta f \geq 1000$)	80	1	1	90	7	93	10

Note: The parameters used in the calculations below are:

Height of the antenna of the (undesired) VOR is 20 ft above local terrain.

Height of the antenna of the (undesired) Localizer is 6 ft above local terrain.

Height of the (desired) VDB aircraft is 10.000 ft.

ITU-R aeronautical propagation curves (Recommendation P.528-4) for 112 MHz, 5% of the time

4.4.12 Interference from VHF-COM signals

4.4.12.1 On-board compatibility

No frequency assignment planning constraints have been identified to secure the compatibility between the on-board transmission of VHF-COM signals and the reception of GBAS/VDB signals on the same aircraft.

Air-to-air interference can be expected as in Table 4.15.

Table 4.15 Minimum separation distances between aircraft

ΔF (kHz)	D/U	10dBW		14 dBW		17dBW		20 dBW	
		L (dB)	D(NM)	L (dB)	D(NM)	L (dB)	D(NM)	L (dB)	D(NM)
50	-34 dB	78	< 1	82	1.5	85	3	88	4.5
75	-39 dB	73	< 1	77	< 1	80	< 1	83	2
100	-42 dB	70	< 1	76	< 1	77	< 1	80	1
125	-46 dB	66	< 1	70	< 1	79	< 1	76	< 1

The minimum separation distances as in Table 4.15 were calculated assuming isotropic antennas on board the desired and the undesired aircraft. Taking into account that the effect of the actual antenna diagram of the VHF-COM and the GBAS/VDB antenna as well as the transient effect of air-to-air interference, at a frequency separation greater than 100 kHz no air-to-air interference is expected.

Note: An aircraft EIRP of 20 dBW (100 W) is not normally used. For aircraft EIRP of 17dBW (50 W) or less, a minimum frequency separation between the aircraft VHF-COM and the GBAS/VDB receiver of 50 [58.3] kHz may be recommended.

4.4.12.2 Ground-to-air interference

At short distances, as shown in Table 4.15, interference from a VHF-Ground facility can be expected when the EIRP of the ground station is between 14 dBW (25W) to 20 dBW (100W). Maintaining a minimum frequency separation of 100 kHz between the assigned GBAS/VDB and VHF-COM frequency would avoid such interference. One option is to ensure in the frequency assignment planning process that a guard band of 100 kHz is introduced which would exclude the frequencies between 117.900 – 117.975 MHz to be used for GBAS/VDB.

Note: This condition seems to be extremely conservative. Taking into account the actual antenna diagram and the geography of short distances to the (interfering) VHF COM station, it may be sufficient to only exclude the frequency 117.950 MHz from being assigned to a GBAS/VDB station.

4.5 Distance Measuring Equipment (DME)

4.5.1 Frequency band and channel spacing

4.5.1.1 The DME operates on paired interrogation and reply frequencies (each combination of these frequencies is a “channel”) in the frequency band 960 – 1215MHz. A number of these channels are in turn paired with ILS or VOR frequencies. The DME channelling arrangement is shown in Appendix D. [DOC9718, Vol 2, 5.3.1]

Note: The frequency band 960 – 1215 MHz is also used for TACAN. TACAN operates with the same channeling scheme as the DME and can be paired with a VOR (VOR/TAC). From the frequency assignment planning point of view TACAN is equivalent to DME.

4.5.1.2 The spacing between DME channels is 1MHz. DME X and Y channels with the same channel number use the same interrogator frequency but with different pulse coding. The reply frequency for the X and Y channel is different as well as the pulse coding. The Y channels reuse the reply frequencies within the interrogation frequency block (1025 – 1150 MHz).

4.5.2 [DOC] The Designated Operational Coverage (DOC) of the DME is normally as promulgated by States/Administrations. When the DME is associated with an ILS or a VOR, the DOC of the DME is normally not less than the DOC of the ILS or VOR. [DOC9718, Vol, 5.2.1]

4.5.3 [PFD limit] The peak equivalent isotopically radiated power shall not be less than that required to ensure a peak pulse power density of minus 89 dBW/m² under all operational weather conditions at any point within coverage. Minus 111 dBW at the antenna corresponds to a power flux density of minus 89 dBW/m² at the mid-band frequency.

4.5.4 [Facility code] Information on the planning of identifications can be found in section 4.6.

4.5.5 Protection requirements

Notes: For frequency planning purposes,

- 1) There is no difference between DME/N and DME/P.*
- 2) TACAN facilities are treated in the same way as DME stations.*
- 3) No criteria are defined for DME/W and DME/Z.*

4.5.5.1 The necessary desired to undesired (D/U) signal ratios needed to protect the desired transponder reply signal at an airborne receiver from the various co-frequency/adjacent frequency, same code/different code, undesired transponder reply signal combinations that may exist. [ANN10, Vol 1, Attachment C, 7.1.8.1]

4.5.5.2 The prerequisite for any D/U calculation to be valid is that the minimum signal of the (desired) DME (-111dBW) at the aircraft antenna is achieved at all points throughout the coverage.

4.5.5.3 In making an assignment, each DME facility must be treated as the desired source with the other acting as the undesired. If both satisfy their unique D/U requirement, then the channel assignment may be made. This “reverse” check is necessary if the DME facilities being considered radiate with different EIRP or have a different DOC. [DOC9718, Vol 2, 5.7.7.1]

4.5.5.4 To each X or Y DME channel corresponds a specific reply frequency within the band 960 - 1215 MHz. X and Y DME channels do not have reply frequencies in common. Hence, for the protection of the desired transponder replies from other co-channel transponder replies, it is sufficient to consider only DME facilities with the same channel designation

(including the pulse code). However, for DME facilities operating on Y channels, the reply frequency may be the same as the interrogator frequency of another DME X facility. [DOC9718, Vol 2, 5.7.1.3]

4.5.5.5 For co-channel assignments, the D/U signal ratio should be at least 8 dB throughout the service volume. [ANN10, Vol 1, Attachment D, 7.1.8.2]

4.5.5.6 For Adjacent frequency assignments, the minimum required D/U ratio within the operational service volume shall be in accordance with the values given in Table 4.16. [ANN10, Vol 1, Attachment D, 7.1.8.2]

The following values are assumed for the adjacent-channel emissions of the transponder (P_u):

200 mW (-7 dBW) on the first adjacent frequency;

2 mW (-27 dBW) on the second adjacent frequency.

Table 4.16 Minimum separation distances between the DME Ground Station

Type of assignment	A	B
Co-frequency:		
Same pulse code	8	8
Different pulse code	8	-43
First adjacent frequency:		
Same pulse code	$-(P_u - 1)$	-42
Different pulse code	$-(P_u + 7)$	-75
Second adjacent frequency:		
Same pulse code	$-(P_u + 19)$	-75
Different pulse code	$-(P_u + 27)$	-75
<i>Note 1: The D/U ratios in column A protect those DME/N interrogators operating on X or Y channels. Column A applies to decoder rejection of 6 microseconds.</i> <i>Note 2: The D/U ratios in column B protect those DME/N or DME/P interrogators utilizing discrimination in conformance with 3.5.5.3.4.2 and 3.5.5.3.4.3 of Chapter 3, Annex 10, Volume I and providing a decoder rejection conforming to 3.5.5.3.5 of Chapter 3, Annex 10, Volume I</i> <i>Note 3: P_u is the peak effective radiated power of the undesired signal in dBW.</i> <i>Note 4: The frequency protection requirement is dependent upon the antenna patterns of the desired and undesired facility and the EIRP of the undesired facility.</i> <i>Note 5: In assessing adjacent channel protection, the magnitude of D/U ratio in column A should not exceed the magnitude of the value in column B.</i>		

4.5.5.7 Separation requirement for DME reply frequencies which are separated by 63MHz. The channel assignment plan for DME is such that the transponder reply frequency for each Y channel is the same as the interrogation frequency of another DME channel. When the reply frequency of one DME matches the interrogation frequency of a second DME, a minimum separation distance of 15 NM (28km) between these (ground) facilities would be required, in general.

4.5.5.8 Table 4.17 to Table 4.19 present the co- and adjacent frequency separation distance between the edge of the DOC of the (desired) DME and the location of the (undesired) DME.

Table 4.17 Minimum separation distances between desired DME and undesired DME

ΔF (MHz)	D/U (dB)	Tx = 27 dBW		Tx = 30 dBW		Tx=37 dBW		Remarks
		L (dB)	D (NM)	L (dB)	D (NM)	L (dB)	D (NM)	
0	8	146	256	149	260	156	265	co-channel
1	8	112	3	112	3	112	3	first adjacent channel
63			15		15		15	

Table 4.18 Minimum separation distances between desired DME and undesired DME

ΔF (MHz)	D/U (dB)	Tx = 27 dBW		Tx = 30 dBW		Tx=37 dBW		Remarks
		L (dB)	D (NM)	L (dB)	D (NM)	L (dB)	D (NM)	
0	8	146	197	149	200	156	204	co-channel
1	8	112	6	112	6	112	6	first adjacent channel
63			15		15		15	

Table 4.19 Minimum separation distances between desired DME and undesired DME

ΔF (MHz)	D/U (dB)	Tx = 27 dBW		Tx = 30 dBW		Tx=37 dBW		Remarks
		L (dB)	D (NM)	L (dB)	D (NM)	L (dB)	D (NM)	Desired DME at 10000 ft
0	8	146	131	149	133	156	137	co-channel
1	8	112	5	112	5	112	5	first adjacent channel
63			15		15		15	

Note1: The separation distances are between the edge of coverage for a desired DME and the location of an undesired DME. The EIRP of the undesired DME is as specified in column "Tx".

Note2: ITU-R aeronautical propagation curve for 1080 MHz and 5% of the time. The antenna height of the desired aircraft receiver is indicated in the "Remarks" column, and the antenna height of undesired DME is 20 ft.

4.5.6 Sectorized DOC of the DME [DOC9718, Vol 2, 5.11]

Similar to VOR (as described in section 4.3), the DME DOC may be sectorized (instead of circular). In this case, compatibility of the DME with other DME assignments needs to be assured at the critical point which is the closest point of the DOC of the desired DME (with sectorized DOC) and any potential interfering DME transponder.

4.5.7 Use of directional antenna [DOC9718, Vol 2, 5.12]

4.5.7.1 When omnidirectional DOC is not required, the use of a DME with directional antenna is encouraged, subject to the proviso that the operational requirements for the service to be provided by this facility are met. In Particular, they are useful for the replacement of ILS marker beacons. The directional DME could provide a means to mitigate frequency congestion.

4.5.7.2 The compatibility of DMEs with directional antennas can be examined basically along the same lines as those developed for omnidirectional DME. However, because of the variable antenna gain of a DME with directional antenna, the value of the quantity K (EIRP of the desired minus the EIRP of the undesired facility) in the above formulas depends in general on the position of the airborne receiver. It is noted in particular that because of the orientation of a DME with directional antenna, the minimum D/U value is not necessarily attained along the direct line connecting desired and undesired facilities, as opposed to the case of compatibility between omnidirectional DME.

4.5.7.3 In the presence of at least one DME with directional antenna, the following method should be applied. At first an appropriate number of points is selected along the edge of the DOC of the desired DME, regardless of the type of its antenna. Subsequently at all such points the required D/U criteria are checked. Compatibility is ensured if at all such points the required D/U criteria are met.

4.6 Identifications of Radio Navigation Aids

4.6.1 Identifications of navigation aids shall be so composed, if possible, as to facilitate association with the name of the point in plain language. The Table 4.20 provides an overview of the requirements which have to be taken into account for identifications.

Table 4.20 The requirements have to be taken into account for identifications

Facility	Identification	Remarks
NDB and Locator	2 or 3 letters of the International Morse Code.	
ILS	2 or 3 letters of the International Morse Code which may be preceded by the letter I.	Transmitted by the localizer.
ILS/DME	ILS: 2 or 3 letters of the International Morse Code which may be preceded by the letter I. DME: Identical to associated ILS.	Associated DME identification signal.
VOR	2 or 3 letters of the International Morse Code.	
VOR/DME (VOR/TACAN also called VORTAC)	VOR: 2 or 3 letters of the International Morse Code. DME: Identical to associated VOR.	Associated DME identification signal.

DME (TACAN)	Letters and numerals of the International Morse Code.	Independent DME identification signal for stand-alone DME facility.
GBAS	4 characters (Only upper case letters, numeric digits and IA-5 “space” are used. The rightmost character is transmitted first. For a three-character GBAS ID, the rightmost (first transmitted) character shall be IA-5 “space”.)	

4.6.2 The identification TST is reserved for radio navigation facilities on test and should not be used for other purposes.

4.6.3 Coded identification shall not be duplicated within 1 100 km (600 NM) of the location of the radio navigation aid concerned, except as noted hereunder. [ANN11, Appendix 2, 2.2.2]

Note: When two radio navigation aids operating in different bands of the frequency spectrum are situated at the same location, their radio identifications are normally the same.

4.6.4 States/Administrations’ requirements for identifications shall be notified to the Regional Offices for coordination.

Appendix A

TEMPLATE FOR AN EXCEL OR WORD FILE THAT CAN BE USED FOR ELECTRONIC SUBMISSION OF ONE (OR MORE) NEW OR MODIFIED FREQUENCY ASSIGNMENTS FOR NAV SYSTEMS TO THE REGIONAL OFFICE

Essential characteristics should to be included in the submission to the Regional Office:

Country	
Location	
Latitude	
Longitude	
Frequency	
Channel	
VHFDOC	
VHFPwr	
DMEDOC	
DMEPwr	
Cat	
Remarks	
TRD	

In the table, the following format should be used:

Country	Country name as per ICAO directory	
Location	Name of the location of the NAV facility	
Latitude	Latitude in the format xxDyy'zz'' (e.g. 32D44'55'')	
Longitude	Longitude in the format xxxDyy'zz'' (e.g.054D55'56'')	
Facility	Select one of the following facilities	
	- ILS - ILS/DME - VOR - VOR/DME - DME - TACAN - GBAS	
Frequency	xxx.yyy (e.g. 109.200 or 113.450) [MHz]	
	<i>A frequency can be proposed by a State or selected by the Regional Office and is subject to a compatibility assessment with or frequency assignments in the COM list 2</i>	
Channel	DME channel (e.g. 36X or 45Y)	
VHFDOC	xxx/yyy e.g. 200/250	xxx is the range of the coverage (e.g. 200 is 200 NM) yyy is the height (FL) of the coverage (e.g. 250 is FL 250 or 25000ft)
DMEDOC	xxx/yyy e.g. 200/250	xxx is the range of the DME coverage (e.g. 200 is 200 NM) yyy is the height (FL) of the DME coverage (e.g. 250 is FL 250 or 25000ft)
Remarks	Optional, as provided by the State	
Cat	Category; either ICAO or NAT	
VHFPwr	As provided by the State	
DMEPwr	As provided by the State	

Note: The values for VHFPwr and DMEPwr are for the effective isotopically radiated power (e.i.r.p) of the relevant facility. In the absence of such information, the following values are assumed in the frequency assignment planning process:

Appendix A

ILS/Localizer	30 dBW	
ILS/DME	27 dBW (e.i.r.p for the associated DME)	
VOR	Range <50 NM	e.i.r.p 17 dBW
	Range 50 – 100 NM	e.i.r.p 20 dBW
	Range 100 – 150 NM	e.i.r.p 23 dBW
	Range > 150 NM	e.i.r.p 30 dBW
VOR/DME	Range <50 NM	e.i.r.p 27 dBW (landing DME)
	Range 150 -150 NM	e.i.r.p 30 dBW (terminal DME)
	Rnage >150 NM	e.i.r.p 37 dBW (en route DME)
DME only	as for DME associated with VOR.	
<i>The e.i.r.p values for DME apply also for TACAN facilities</i>		
TRD	Runway azimuth	

Appendix B

PREFERRED FORMAT OF THE CHARACTERISTICS OF SUBMISSIONS

Reference of submission:

Date:

Subject: Application for xx, at xx (location name)

Contact information of the civil aviation authority of States

Suggested basic information of a submission:

Function of the proposed assignments,

Details of the facility: Manufacturer & Model (if possible),

Frequency Range (if request RO for proposal) or proposed frequency,

Transmit Power or DOC

Latitude/Longitude:

Minimum information required with reference to the following screenshot:

Country, Location, Latitude/Longitudes, Service.

The screenshot shows a software interface for entering station data. The title bar is 'Station'. The interface includes several input fields and buttons. On the left, there is a vertical menu with 'Insert from memory' and 'Type name'. The main area contains fields for 'Region' (APAC), 'Key' (D 420458), 'Cat', 'Channel spacing' (25 kHz, 8.33 kHz), 'Country' (Ctry), 'Location', 'Latitude' (D, N, S, E, W), 'Longitude' (D, N, S, E, W), 'Frequency' (0.000), 'Service' (dropdown), 'Stat' (dropdown), 'DOC' (dropdown with options: Drop down disabled, MOD Range (NM), MOD Height (feet)), 'ER family' (Example: ER-BOT-1), 'PolyID' (dropdown), 'Required fields' (FIR SECTORNAME), 'Remarks', and 'Upload Status' (DN). A 'TEST' button is at the bottom left.

Appendix C

REGIONAL 117.975-137MHz FREQUENCY ALLOTMENT PLAN

Function	Frequencies (MHz)
TWR	118.000 118.025 118.050 118.075 118.100 118.125 118.150 118.175 118.200 118.225 118.250 118.275 118.300 118.325 118.350 118.375 118.400 118.425 118.450 118.475 118.500 118.525 118.550 118.575 118.600 118.625 118.650 118.675 118.700 118.725 118.750 118.775 118.800 118.825 118.850 118.875 124.300 124.325 124.350 124.375
AS	121.550 121.575 121.600 121.625 121.650 121.675 121.700 121.725 121.750 121.775 121.800 121.825 121.850 121.875 121.900 121.925 121.950 121.975
APP	119.500 119.525 119.550 119.575 119.600 119.625 119.650 119.675 119.800 119.825 119.850 119.875 119.900 119.925 119.950 119.975
APP-L, APP-I, Also used for APP Direction finding or APP Surveillance radar	119.000 119.025 119.050 119.075 119.100 119.125 119.150 119.175 119.200 119.225 119.250 119.275 119.400 119.425 119.450 119.475 119.700 119.725 119.750 119.775 120.000 120.025 120.050 120.075 120.200 120.225 120.250 120.275 120.400 120.425 120.450 120.475 120.600 120.625 120.650 120.675 120.800 120.825 120.850 120.875 121.000 121.025 121.050 121.075 121.100 121.125 121.150 121.175 121.200 121.225 121.250 121.275 121.400 121.425 121.450 123.800 123.825 123.850 123.875 124.000 124.025 124.050 124.075 124.700 124.725 124.750 124.775 125.100 125.125 125.150 125.175 125.500 125.525 125.550 125.575 126.500 126.525 126.550 126.575 127.700 127.725 127.750 127.775 127.900 127.925 127.950 127.975
APP-U	120.300 120.325 120.350 120.375 121.300 121.325 121.350 121.375 124.200 124.225 124.250 124.275 124.400 124.425 124.450 124.475

	124.600 124.625 124.650 124.675 124.800 124.825 124.850 124.875 125.000 125.025 125.050 125.075 125.200 125.225 125.250 125.275 125.400 125.425 125.450 125.475 125.600 125.625 125.650 125.675 125.800 125.825 125.850 125.875 126.000 126.025 126.050 126.075 126.300 126.325 126.350 126.375
ACC-L Also used for ACC-L Surveillance Radar	126.100 126.125 126.150 126.175 127.500 127.525 127.550 127.575 128.300 128.325 128.350 128.375 128.700 128.725 128.750 128.775
ACC-U ACC-L	118.900 118.925 118.950 118.975 119.300 119.325 119.350 119.375 120.500 120.525 120.550 120.575 120.700 120.725 120.750 120.775 120.900 120.925 120.950 120.975 123.700 123.725 123.750 123.775 124.500 124.525 124.550 124.575 125.300 125.325 125.350 125.375 125.700 125.725 125.750 125.775 125.900 125.925 125.950 125.975 128.100 128.125 128.150 128.175 132.050 132.075 132.100 132.125 132.150 132.175 132.200 132.225 132.250 132.275 132.300 132.325 132.350 132.375 132.400 132.425 132.450 132.475 132.500 132.525 132.550 132.575 132.600 132.625 132.650 132.675 132.700 132.725 132.750 132.775 132.800 132.825 132.850 132.875 132.900 132.925 132.950 132.975 133.000 133.025 133.050 133.075 133.100 133.125 133.150 133.175 133.200 133.225 133.250 133.275 133.300 133.325 133.350 133.375 133.400 133.425 133.450 133.475 133.500 133.525 133.550 133.575 133.600 133.625 133.650 133.675 133.700 133.725 133.750 133.775 133.800 133.825 133.850 133.875 133.900 133.925 133.950 133.975 134.000 134.025 134.050 134.075 134.100 134.125 134.150 134.175 134.200 134.225 134.250 134.275 134.300 134.325 134.350 134.375 134.400 134.425 134.450 134.475 134.500 134.525 134.550 134.575 135.825 135.850 135.875 135.900 135.925 135.950 135.975
FIS-L FIS-U	120.100 120.125 120.150 120.175 123.900 123.925 123.950 123.975

	124.100 124.125 124.150 124.175 124.900 124.925 124.950 124.975 126.700 126.725 126.750 126.775 126.900 126.925 126.950 126.975 127.100 127.125 127.150 127.175 127.300 127.325 127.350 127.375 128.500 128.525 128.550 128.575
FIS-U Also used for General purpose communications	134.600 134.625 134.650 134.675 134.700 134.725 134.750 134.775 134.800 134.825 134.850 134.875 134.900 134.925 134.950 134.975 135.000 135.025 135.050 135.075 135.100 135.125 135.150 135.175 135.200 135.225 135.250 135.275 135.300 135.325 135.350 135.375 135.400 135.425 135.450 135.475 135.500 135.525 135.550 135.575 135.600 135.625 135.650 135.675 135.700 135.725 135.750 135.775 135.800
VOLMET/ATIS	126.200 126.225 126.250 126.275 126.400 126.425 126.450 126.475 126.600 126.625 126.650 126.675 126.800 126.825 126.850 126.875 127.000 127.025 127.050 127.075 127.200 127.225 127.250 127.275 127.400 127.425 127.450 127.475 127.600 127.625 127.650 127.675 127.800 127.825 127.850 127.875 128.000 128.025 128.050 128.075 128.200 128.225 128.250 128.275 128.400 128.425 128.450 128.475 128.600 128.625 128.650 128.675 128.800 128.825 128.850 128.875
AOC	128.900-132.025
DATA LINK	136.000-136.975
AIR-TO-AIR	123.450 128.950 (TIBA)
NOT ALLOTTED	122.000-123.675

Note: The allotment of 12 frequencies to ACC shown in italics, which are 132.050 MHz, 132.075 MHz, 134.525 MHz, 134.550 MHz, 134.575 MHz, 135.825 MHz, 135.850 MHz, 135.875 MHz, 135.900 MHz, 135.925 MHz, 135.950 MHz, 135.975 MHz, requires further study and confirmation.

Frequency (MHz)	Service	Power (W)	Notes
118.000 - 118.100	TWR	100	International and National Aeronautical Mobile Services
118.100 - 118.200	TWR	100	
118.200 - 118.300	TWR	100	
118.300 - 118.400	TWR	100	
118.400 - 118.500	TWR	100	
118.500 - 118.600	TWR	100	
118.600 - 118.700	TWR	100	
118.700 - 118.800	TWR	100	
118.800 - 118.900	TWR	100	
118.900 - 119.000	TWR	100	
119.000 - 119.100	ACC-U	100	International and National Aeronautical Mobile Services
119.100 - 119.200	ACC-U	100	
119.200 - 119.300	ACC-U	100	
119.300 - 119.400	ACC-U	100	
119.400 - 119.500	ACC-U	100	
119.500 - 119.600	ACC-U	100	
119.600 - 119.700	ACC-U	100	
119.700 - 119.800	ACC-U	100	
119.800 - 119.900	ACC-U	100	
119.900 - 120.000	ACC-U	100	
120.000 - 120.100	APP	100	International and National Aeronautical Mobile Services
120.100 - 120.200	APP	100	
120.200 - 120.300	APP	100	
120.300 - 120.400	APP	100	
120.400 - 120.500	APP	100	
120.500 - 120.600	APP	100	
120.600 - 120.700	APP	100	
120.700 - 120.800	APP	100	
120.800 - 120.900	APP	100	
120.900 - 121.000	APP	100	
121.000 - 121.100	APP-L	100	International and National Aeronautical Mobile Services
121.100 - 121.200	APP-L	100	
121.200 - 121.300	APP-L	100	
121.300 - 121.400	APP-L	100	
121.400 - 121.500	APP-L	100	
121.500 - 121.600	APP-L	100	
121.600 - 121.700	APP-L	100	
121.700 - 121.800	APP-L	100	
121.800 - 121.900	APP-L	100	
121.900 - 122.000	APP-L	100	
122.000 - 122.100	APP-L	100	International and National Aeronautical Mobile Services
122.100 - 122.200	APP-L	100	
122.200 - 122.300	APP-L	100	
122.300 - 122.400	APP-L	100	
122.400 - 122.500	APP-L	100	
122.500 - 122.600	APP-L	100	
122.600 - 122.700	APP-L	100	
122.700 - 122.800	APP-L	100	
122.800 - 122.900	APP-L	100	
122.900 - 123.000	APP-L	100	
123.000 - 123.100	APP-L	100	International and National Aeronautical Mobile Services
123.100 - 123.200	APP-L	100	
123.200 - 123.300	APP-L	100	
123.300 - 123.400	APP-L	100	
123.400 - 123.500	APP-L	100	
123.500 - 123.600	APP-L	100	
123.600 - 123.700	APP-L	100	
123.700 - 123.800	APP-L	100	
123.800 - 123.900	APP-L	100	
123.900 - 124.000	APP-L	100	
124.000 - 124.100	APP-L	100	International and National Aeronautical Mobile Services
124.100 - 124.200	APP-L	100	
124.200 - 124.300	APP-L	100	
124.300 - 124.400	APP-L	100	
124.400 - 124.500	APP-L	100	
124.500 - 124.600	APP-L	100	
124.600 - 124.700	APP-L	100	
124.700 - 124.800	APP-L	100	
124.800 - 124.900	APP-L	100	
124.900 - 125.000	APP-L	100	
125.000 - 125.100	APP-L	100	International and National Aeronautical Mobile Services
125.100 - 125.200	APP-L	100	
125.200 - 125.300	APP-L	100	
125.300 - 125.400	APP-L	100	
125.400 - 125.500	APP-L	100	
125.500 - 125.600	APP-L	100	
125.600 - 125.700	APP-L	100	
125.700 - 125.800	APP-L	100	
125.800 - 125.900	APP-L	100	
125.900 - 126.000	APP-L	100	
126.000 - 126.100	APP-L	100	International and National Aeronautical Mobile Services
126.100 - 126.200	APP-L	100	
126.200 - 126.300	APP-L	100	
126.300 - 126.400	APP-L	100	
126.400 - 126.500	APP-L		

Appendix D

GENERIC CALCULATION METHOD FOR GEOGRAPHICAL SEPARATION DISTANCES

- a. For the calculation of minimum separation distances with a (desired) facility and an (undesired) facility the generic model as described in Chapter 1 of DOC 9718 has been established.
- b. To establish minimum geographical separation distances between a desired facility and an undesired facility, the following parameters are used:
 - a) The minimum received desired power P_d of the desired facility (dBW).
 - b) D/U ratio. The prerequisite for any D/U calculation to be valid is that the minimal receive power is achieved at all points throughout the coverage.
 - c) ERIP of the undesired facility T_x (dBW).
 - d) Designated operational range of the desired facility.
 - e) ITU-R aeronautical propagation curve for 5% of the time.
- c. The generic method establishes the minimum geographical separation distance between the edge of the DOC of the desired facility and undesired facility. This distance provides for the transmission loss (attenuation) of the undesired signal to a level that meets the D/U requirement for the desired signal, $L = T_x - P_d + D/U$. This distance is obtained with using the relevant (frequency) ITU propagation curve applicable for the maximum height of the DOC of the desired facility and the site elevation of the undesired facility.
- d. When the minimum distance from the edge of coverage from the desired facility to the undesired facility has been established, the station-to-station separation distance can be obtained by adding the DOR to the minimum distance from the edge of coverage to the undesired facility.
- e. These steps need to be undertaken in the reverse direction whereby the desired facility becomes the undesired facility and the undesired facility becomes the desired facility. The maximum distance between the two processes determine the minimum separation between the two facilities.

Appendix E

PAIRING OF ILS/VOR/DME CHANNELS

Source: Annex 10, Volume 1, Table A			DME parameters					
			Interrogation				Reply	
				Pulse codes				
Channel pairing					DME/P mode			
DME channel number	VHF frequency MHz	GS frequency MHz	Frequency MHz	DME/N μ s	Initial approach μ s	Final approach μ s	Frequency MHz	Pulse codes μ s
* 1X	–	–	1 025	12	–	–	962	12
** 1Y	–	–	1 025	36	–	–	1 088	30
* 2X	–	–	1 026	12	–	–	963	12
** 2Y	–	–	1 026	36	–	–	1 089	30
* 3X	–	–	1 027	12	–	–	964	12
** 3Y	–	–	1 027	36	–	–	1 090	30
* 4X	–	–	1 028	12	–	–	965	12
** 4Y	–	–	1 028	36	–	–	1 091	30
* 5X	–	–	1 029	12	–	–	966	12
** 5Y	–	–	1 029	36	–	–	1 092	30
* 6X	–	–	1 030	12	–	–	967	12
** 6Y	–	–	1 030	36	–	–	1 093	30
* 7X	–	–	1 031	12	–	–	968	12
** 7Y	–	–	1 031	36	–	–	1 094	30
* 8X	–	–	1 032	12	–	–	969	12
** 8Y	–	–	1 032	36	–	–	1 095	30
* 9X	–	–	1 033	12	–	–	970	12
** 9Y	–	–	1 033	36	–	–	1 096	30
* 10X	–	–	1 034	12	–	–	971	12
** 10Y	–	–	1 034	36	–	–	1 097	30
* 11X	–	–	1 035	12	–	–	972	12
** 11Y	–	–	1 035	36	–	–	1 098	30
* 12X	–	–	1 036	12	–	–	973	12
** 12Y	–	–	1 036	36	–	–	1 099	30
* 13X	–	–	1 037	12	–	–	974	12
** 13Y	–	–	1 037	36	–	–	1 100	30
* 14X	–	–	1 038	12	–	–	975	12
** 14Y	–	–	1 038	36	–	–	1 101	30

Appendix E

*	15X	—	—	1 039	12	—	—	976	12
**	15Y	—	—	1 039	36	—	—	1 102	30
*	16X	—	—	1 040	12	—	—	977	12
**	16Y	—	—	1 040	36	—	—	1 103	30
?	17X	108		1 041	12	—	—	978	12
	17Y	108.05		1 041	36	36	42	1 104	30
	18X	108.1	334.7	1 042	12	12	18	979	12
	18Y	108.15	334.55	1 042	36	36	42	1 105	30
	19X	108.2		1 043	12	—	—	980	12
	19Y	108.25		1 043	36	36	42	1 106	30
	20X	108.3	334.1	1 044	12	12	18	981	12
	20Y	108.35	333.95	1 044	36	36	42	1 107	30
	21X	108.4		1 045	12	—	—	982	12
	21Y	108.45		1 045	36	36	42	1 108	30
	22X	108.5	329.9	1 046	12	12	18	983	12
	22Y	108.55	329.75	1 046	36	36	42	1 109	30
	23X	108.6		1 047	12	—	—	984	12
	23Y	108.65		1 047	36	36	42	1 110	30
	24X	108.7	330.5	1 048	12	12	18	985	12
	24Y	108.75	330.35	1 048	36	36	42	1 111	30
	25X	108.8		1 049	12	—	—	986	12
	25Y	108.85		1 049	36	36	42	1 112	30
	26X	108.9	329.3	1 050	12	12	18	987	12
	26Y	108.95	329.15	1 050	36	36	42	1 113	30
	27X	109		1 051	12	—	—	988	12
	27Y	109.05		1 051	36	36	42	1 114	30
	28X	109.1	331.4	1 052	12	12	18	989	12
	28Y	109.15	331.25	1 052	36	36	42	1 115	30
	29X	109.2		1 053	12	—	—	990	12
	29Y	109.25		1 053	36	36	42	1 116	30
	30X	109.3	332.0	1 054	12	12	18	991	12
	30Y	109.35	331.85	1 054	36	36	42	1 117	30
	31X	109.4		1 055	12	—	—	992	12
	31Y	109.45		1 055	36	36	42	1 118	30

32X	109.5	332.6	1 056	12	12	18	993	12
32Y	109.55	332.45	1 056	36	36	42	1 119	30
33X	109.6		1 057	12	–	–	994	12
33Y	109.65		1 057	36	36	42	1 120	30
34X	109.7	333.2	1 058	12	12	18	995	12
34Y	109.75	333.05	1 058	36	36	42	1 121	30
35X	109.8		1 059	12	–	–	996	12
35Y	109.85		1 059	36	36	42	1 122	30
36X	109.9	333.8	1 060	12	12	18	997	12
36Y	109.95	333.65	1 060	36	36	42	1 123	30
37X	110		1 061	12	–	–	998	12
37Y	110.05		1 061	36	36	42	1 124	30
38X	110.1	334.4	1 062	12	12	18	999	12
38Y	110.15	334.25	1 062	36	36	42	1 125	30
39X	110.2		1 063	12	–	–	1 000	12
39Y	110.25		1 063	36	36	42	1 126	30
40X	110.3	335.0	1 064	12	12	18	1 001	12
40Y	110.35	334.85	1 064	36	36	42	1 127	30
41X	110.4		1 065	12	–	–	1 002	12
41Y	110.45		1 065	36	36	42	1 128	30
42X	110.5	329.6	1 066	12	12	18	1 003	12
42Y	110.55	329.45	1 066	36	36	42	1 129	30
43X	110.6		1 067	12	–	–	1 004	12
43Y	110.65		1 067	36	36	42	1 130	30
44X	110.7	330.2	1 068	12	12	18	1 005	12
44Y	110.75	330.05	1 068	36	36	42	1 131	30
45X	110.8		1 069	12	–	–	1 006	12
45Y	110.85		1 069	36	36	42	1 132	30
46X	110.9	330.8	1 070	12	12	18	1 007	12
46Y	110.95	330.65	1 070	36	36	42	1 133	30
47X	111		1 071	12	–	–	1 008	12
47Y	111.05		1 071	36	36	42	1 134	30
48X	111.1	331.7	1 072	12	12	18	1 009	12

Appendix E

	48Y	111.15	331.55	1 072	36	36	42	1 135	30
	49X	111.2		1 073	12	–	–	1 010	12
	49Y	111.25		1 073	36	36	42	1 136	30
	50X	111.3	332.3	1 074	12	12	18	1 011	12
	50Y	111.35	332.15	1 074	36	36	42	1 137	30
	51X	111.4		1 075	12	–	–	1 012	12
	51Y	111.45		1 075	36	36	42	1 138	30
	52X	111.5	332.9	1 076	12	12	18	1 013	12
	52Y	111.55	332.75	1 076	36	36	42	1 139	30
	53X	111.6		1 077	12	–	–	1 014	12
	53Y	111.65		1 077	36	36	42	1 140	30
	54X	111.7	333.5	1 078	12	12	18	1 015	12
	54Y	111.75	333.35	1 078	36	36	42	1 141	30
	55X	111.8		1 079	12	–	–	1 016	12
	55Y	111.85		1 079	36	36	42	1 142	30
	56X	111.9	331.1	1 080	12	12	18	1 017	12
	56Y	111.95	330.95	1 080	36	36	42	1 143	30
	57X	112		1 081	12	–	–	1 018	12
	57Y	112.05		1 081	36	–	–	1 144	30
	58X	112.1		1 082	12	–	–	1 019	12
	58Y	112.15		1 082	36	–	–	1 145	30
	59X	112.2		1 083	12	–	–	1 020	12
	59Y	112.25		1 083	36	–	–	1 146	30
**	60X	–		1 084	12	–	–	1 021	12
**	60Y	–		1 084	36	–	–	1 147	30
**	61X	–		1 085	12	–	–	1 022	12
**	61Y	–		1 085	36	–	–	1 148	30
**	62X	–		1 086	12	–	–	1 023	12
**	62Y	–		1 086	36	–	–	1 149	30
**	63X	–		1 087	12	–	–	1 024	12
**	63Y	–		1 087	36	–	–	1 150	30
**	64X	–		1 088	12	–	–	1 151	12
**	64Y	–		1 088	36	–	–	1 025	30

Appendix E

**	65X	—	1 089	12	—	—	1 152	12
**	65Y	—	1 089	36	—	—	1 026	30
**	66X	—	1 090	12	—	—	1 153	12
**	66Y	—	1 090	36	—	—	1 027	30
**	67X	—	1 091	12	—	—	1 154	12
**	67Y	—	1 091	36	—	—	1 028	30
**	68X	—	1 092	12	—	—	1 155	12
**	68Y	—	1 092	36	—	—	1 029	30
**	69X	—	1 093	12	—	—	1 156	12
**	69Y	—	1 093	36	—	—	1 030	30
	70X	112.3	1 094	12	—	—	1 157	12
**	70Y	112.35	1 094	36	—	—	1 031	30
	71X	112.4	1 095	12	—	—	1 158	12
**	71Y	112.45	1 095	36	—	—	1 032	30
	72X	112.5	1 096	12	—	—	1 159	12
**	72Y	112.55	1 096	36	—	—	1 033	30
	73X	112.6	1 097	12	—	—	1 160	12
**	73Y	112.65	1 097	36	—	—	1 034	30
	74X	112.7	1 098	12	—	—	1 161	12
**	74Y	112.75	1 098	36	—	—	1 035	30
	75X	112.8	1 099	12	—	—	1 162	12
**	75Y	112.85	1 099	36	—	—	1 036	30
	76X	112.9	1 100	12	—	—	1 163	12
**	76Y	112.95	1 100	36	—	—	1 037	30
	77X	113	1 101	12	—	—	1 164	12
**	77Y	113.05	1 101	36	—	—	1 038	30
	78X	113.1	1 102	12	—	—	1 165	12
**	78Y	113.15	1 102	36	—	—	1 039	30
	79X	113.2	1 103	12	—	—	1 166	12
**	79Y	113.25	1 103	36	—	—	1 040	30
	80X	113.3	1 104	12	—	—	1 167	12
	80Y	113.35	1 104	36	36	42	1 041	30
	81X	113.4	1 105	12	—	—	1 168	12
	81Y	113.45	1 105	36	36	42	1 042	30

82X	113.5	1 106	12	—	—	1 169	12
82Y	113.55	1 106	36	36	42	1 043	30
83X	113.6	1 107	12	—	—	1 170	12
83Y	113.65	1 107	36	36	42	1 044	30
84X	113.7	1 108	12	—	—	1 171	12
84Y	113.75	1 108	36	36	42	1 045	30
85X	113.8	1 109	12	—	—	1 172	12
85Y	113.85	1 109	36	36	42	1 046	30
86X	113.9	1 110	12	—	—	1 173	12
86Y	113.95	1 110	36	36	42	1 047	30
87X	114	1 111	12	—	—	1 174	12
87Y	114.05	1 111	36	36	42	1 048	30
88X	114.1	1 112	12	—	—	1 175	12
88Y	114.15	1 112	36	36	42	1 049	30
89X	114.2	1 113	12	—	—	1 176	12
89Y	114.25	1 113	36	36	42	1 050	30
90X	114.3	1 114	12	—	—	1 177	12
90Y	114.35	1 114	36	36	42	1 051	30
91X	114.4	1 115	12	—	—	1 178	12
91Y	114.45	1 115	36	36	42	1 052	30
92X	114.5	1 116	12	—	—	1 179	12
92Y	114.55	1 116	36	36	42	1 053	30
93X	114.6	1 117	12	—	—	1 180	12
93Y	114.65	1 117	36	36	42	1 054	30
94X	114.7	1 118	12	—	—	1 181	12
94Y	114.75	1 118	36	36	42	1 055	30
95X	114.8	1 119	12	—	—	1 182	12
95Y	114.85	1 119	36	36	42	1 056	30
96X	114.9	1 120	12	—	—	1 183	12
96Y	114.95	1 120	36	36	42	1 057	30
97X	115	1 121	12	—	—	1 184	12
97Y	115.05	1 121	36	36	42	1 058	30
98X	115.1	1 122	12	—	—	1 185	12

98Y	115.15	1 122	36	36	42	1 059	30
99X	115.2	1 123	12	–	–	1 186	12
99Y	115.25	1 123	36	36	42	1 060	30
100X	115.3	1 124	12	–	–	1 187	12
100Y	115.35	1 124	36	36	42	1 061	30
101X	115.4	1 125	12	–	–	1 188	12
101Y	115.45	1 125	36	36	42	1 062	30
102X	115.5	1 126	12	–	–	1 189	12
102Y	115.55	1 126	36	36	42	1 063	30
103X	115.6	1 127	12	–	–	1 190	12
103Y	115.65	1 127	36	36	42	1 064	30
104X	115.7	1 128	12	–	–	1 191	12
104Y	115.75	1 128	36	36	42	1 065	30
105X	115.8	1 129	12	–	–	1 192	12
105Y	115.85	1 129	36	36	42	1 066	30
106X	115.9	1 130	12	–	–	1 193	12
106Y	115.95	1 130	36	36	42	1 067	30
107X	116	1 131	12	–	–	1 194	12
107Y	116.05	1 131	36	36	42	1 068	30
108X	116.1	1 132	12	–	–	1 195	12
108Y	116.15	1 132	36	36	42	1 069	30
109X	116.2	1 133	12	–	–	1 196	12
109Y	116.25	1 133	36	36	42	1 070	30
110X	116.3	1 134	12	–	–	1 197	12
110Y	116.35	1 134	36	36	42	1 071	30
111X	116.4	1 135	12	–	–	1 198	12
111Y	116.45	1 135	36	36	42	1 072	30
112X	116.5	1 136	12	–	–	1 199	12
112Y	116.55	1 136	36	36	42	1 073	30
113X	116.6	1 137	12	–	–	1 200	12
113Y	116.65	1 137	36	36	42	1 074	30
114X	116.7	1 138	12	–	–	1 201	12
114Y	116.75	1 138	36	36	42	1 075	30

115X	116.8	1 139	12	–	–	1 202	12
115Y	116.85	1 139	36	36	42	1 076	30
116X	116.9	1 140	12	–	–	1 203	12
116Y	116.95	1 140	36	36	42	1 077	30
117X	117	1 141	12	–	–	1 204	12
117Y	117.05	1 141	36	36	42	1 078	30
118X	117.1	1 142	12	–	–	1 205	12
118Y	117.15	1 142	36	36	42	1 079	30
119X	117.2	1 143	12	–	–	1 206	12
119Y	117.25	1 143	36	36	42	1 080	30
120X	117.3	1 144	12	–	–	1 207	12
120Y	117.35	1 144	36	–	–	1 081	30
121X	117.4	1 145	12	–	–	1 208	12
121Y	117.45	1 145	36	–	–	1 082	30
122X	117.5	1 146	12	–	–	1 209	12
122Y	117.55	1 146	36	–	–	1 083	30
123X	117.6	1 147	12	–	–	1 210	12
123Y	117.65	1 147	36	–	–	1 084	30
124X	117.7	1 148	12	–	–	1 211	12
** 124Y	117.75	1 148	36	–	–	1 085	30
125X	117.8	1 149	12	–	–	1 212	12
** 125Y	117.85	1 149	36	–	–	1 086	30
126X	117.9	1 150	12	–	–	1 213	12
** 126Y	117.95	1 150	36	–	–	1 087	30
* These channels are reserved exclusively for national allotments. ** These channels may be used for national allotment on a secondary basis. The primary reason for reserving these channels is to provide protection for the secondary surveillance radar (SSR) system. 108.0 MHz is not scheduled for assignment to ILS service. The associated DME operating channel No. 17X may be assigned for emergency use. The reply frequency of channel No. 17X (i.e. 978 MHz) is also utilized for the operation of the universal access transceiver (UAT). Standards and Recommended Practices for UAT are found in Annex 10, Volume III, Part I, Chapter 12.							

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INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA AND PACIFIC OFFICE

**GBAS safety assessment guidance
related to anomalous ionospheric conditions**

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Adopted by CNS SG/27

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Records of amendments

Amendment Number	Date	Amended by	Comments

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TABLE OF CONTENTS FOR GUIDANCE ON GBAS THREAT MODEL

Preface.....	5
1. Introduction.....	5
1.1. GBAS and its fundamental principles.....	5
1.2. Scope: GBAS ionospheric threat model to mitigate anomalous ionospheric conditions.....	6
1.3. Ionospheric effects on GBAS	7
1.3.1. Propagation delay.....	7
1.3.2. Scintillation effects	8
2. Ionosphere conditions to consider for GBAS safety analysis	8
2.1. Overview of relationship between GBAS safety assessment and ionospheric conditions.....	8
2.2. Nominal conditions bounded by PL (protection level)	9
2.3. Anomalous conditions and ionospheric disturbances to consider.....	9
2.3.1. Storm enhanced density	9
2.3.2. Plasma bubble	9
2.3.3. Other	10
2.4. Ionospheric threat model for GBAS safety analysis	10
2.5. Evaluation of requirements and performance, including integrity monitoring	10
2.5.1. Ranging errors induced by ionospheric anomaly.....	11
2.5.2. Positioning errors in the final implementation	11
2.6. Other important descriptions.....	11
3. Development and validation of the threat model	11
3.1. Observation stage.....	11
3.1.1. Tools like LTIAM (Long Term Ionospheric Anomaly Monitor).....	12
3.1.2. Time Step method	12
3.1.3. Summary of how to develop the ionospheric threat model.....	13
3.2. Simulation approach	14
3.2.1. Three dimensional analysis	14
3.3. Validation.....	14
3.4. GBAS ionospheric threat model for APAC region	14
4. Post-implementation activities.....	15
4.1. Monitoring of ionospheric activity	15
4.2. Maintenance of threat model.....	15
5. References.....	15
6. Annexes	17
6.1. CONUS model.....	17

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

6.2.	Safety analysis for GBAS prototyping in Osaka.....	18
6.3.	Other	18

Preface

The scope of this guidance is to provide high level principles and necessary activities to implement Ground-Based Augmentation System (GBAS) by mitigating threats associated with ionospheric anomalies. Technical details such as necessary observation setup, detailed analysis techniques, or interpretation of analysis results are out of the scope of this document. Such details may be included in the GBAS Manual which is being considered by the ICAO Navigation Systems Panel.

1. Introduction

1.1. GBAS and its fundamental principles

GNSS (Global Navigation Satellite System) is expected to support seamless and flexible aircraft guidance in all flight phases. However, the current GNSS lacks safety performances to support precision approaches because it does not have any functions to timely detect its failure and alert it to aviation users. ICAO defines safety requirements for navigation system as accuracy, integrity, availability and continuity for each flight phases, which are en-route, terminal, non-precision approach (NPA) and precision approach in Annex 10 to the Convention International Civil Aviation [1]. To satisfy the requirements, three types of GNSS augmentation systems are introduced. Ground-Based Augmentation Systems (GBAS) is one of them and its SARPs (Standards And Recommended Practices) are defined in the Annex 10.

GBAS is a navigation system to support aircraft precision approach and landing. SARPs for CAT-I precision approach have been effective since 2001, and ones for CAT-III (GAST D; GBAS Service Type D) have been effective and applicable since 2018. These are based on the single-frequency GPS and/or GLONASS signals at the L1 band. SARPs for GBAS with dual-frequency (L1 and L5 bands) and multi-constellation (all the four standardized constellations including GPS, GLONASS, Galileo and Beidou) GNSS signals are under development. GBAS is based on the "local" differential positioning method which subtracts common error components from each GNSS ranging source signals received at a user's onboard system. The GBAS ground subsystem generates differential correction and integrity messages from three or more (usually four) sets of ground GNSS antenna and receivers (see Figure 1). As major error sources, it is well known that there are satellite ephemeris and clock errors, propagation delays due to the ionosphere and troposphere, where the refractivity is more than one. It is an important fact that these remaining errors in each ranging source after the correction are increased in accordance with distance from the GBAS ground subsystem, namely the centroid of the ground GNSS receivers. Multipath effects are also an error factor for GNSS differential technique on both ground and aircraft that do not increase with distance. However, they can be reduced by averaging measurement data of ranging sources among the multiple ground receivers.

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anomalous ionospheric conditions*

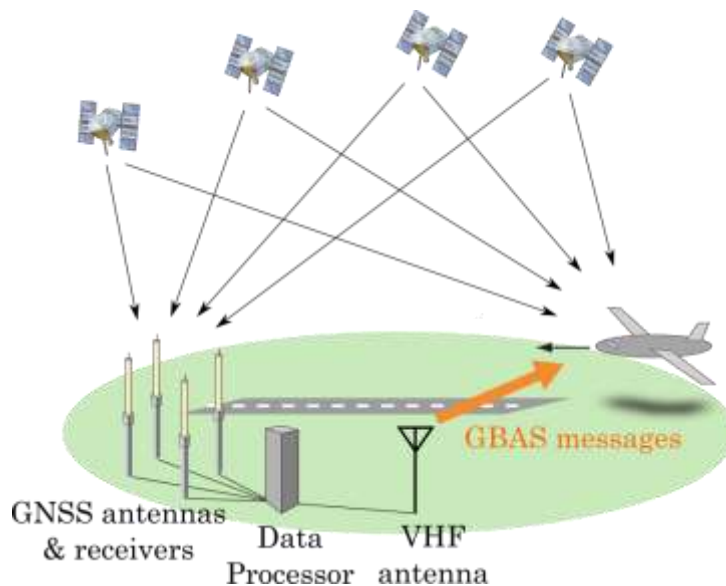


Figure 1. GBAS outline

Because it is necessary for an operational GBAS ground subsystem to meet the stringent safety requirements defined by the SARPs in Annex 10, its validation only by monitoring continuous run behavior is not enough for operational approval of the ground subsystem. A service provider has to prove its system is able to meet the safety requirements specified by its state's aviation safety authority, and each country or regional's regulator has to judge whether it satisfies them or not.

1.2. Scope: GBAS ionospheric threat model to mitigate anomalous ionospheric conditions

Although GBAS is designed to subtract common error components, spatial decorrelation of ionospheric propagation delay is one of error sources for GBAS precision approaches as mentioned above. Namely, effects of GBAS correction for ionospheric delay are worse at far points from GBAS ground station than near ones. Therefore, GBAS takes its effects into account as evaluation parameters, which are broadcasted from ground subsystem to airborne, for calculation reliability of user's final positioning solution. In other words, GBAS protects users from the spatial decorrelation effects of ionospheric delay under "nominal" condition within a certain range that is covered by the evaluation parameters. However, large spatial changes of ionospheric delay which exceed the range assured by the broadcasted evaluation parameters could cause loss of integrity. Figure 2 shows an example scenario of ionospheric delay anomaly, which cannot be detected by GBAS ground subsystem. GBAS ground subsystem should protect users from any ionospheric anomaly in a case of CAT-I approach service in contrast to CAT-III (GAST D), which requires ionospheric anomaly monitors onboard in addition to ground subsystem.

Although a system is safer with consideration of more ionospheric anomalous cases and scenarios, there should be an appropriate safe level enough to meet the targeted requirements. An ionospheric

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

threat model is used to analyze and evaluate impacts of the ionospheric effects on GBAS. The threat model is developed based on ionospheric effects on GBAS considering actual ionospheric characteristics. It also describes threat space for safe GBAS design such as ranges of related parameters to consider. Using the threat model, it is required to evaluate users' remaining integrity risk including simulation analysis. If GBAS could not protect users with a targeted safe level against all possible cases, it is needed to develop mitigation methods to satisfy the requirements. An integrity monitor to detect and exclude anomalous ranging source affected by ionospheric disturbances is one of such mitigation methods. Because GBAS safety requirements include not only integrity but also continuity, required performances of an integrity monitor shall contain a false alert rate as well as a missed detection rate. Note that decrease in available ranging sources due to satellite exclusion by integrity monitor degrades system availability. Thus, the ionospheric threat model is used for evaluation of impacts, development of mitigation method and validation of the final performances. It is important to develop ionospheric threat model appropriate and adequate for safe system design [2]. Because the required integrity level is different between GAST C and GAST D, the threat model parameters may be different in principle. However, as it is difficult to obtain enough amount of data to distinguish between them, it is common to use the same threat model developed conservatively for both GAST C and GAST D.

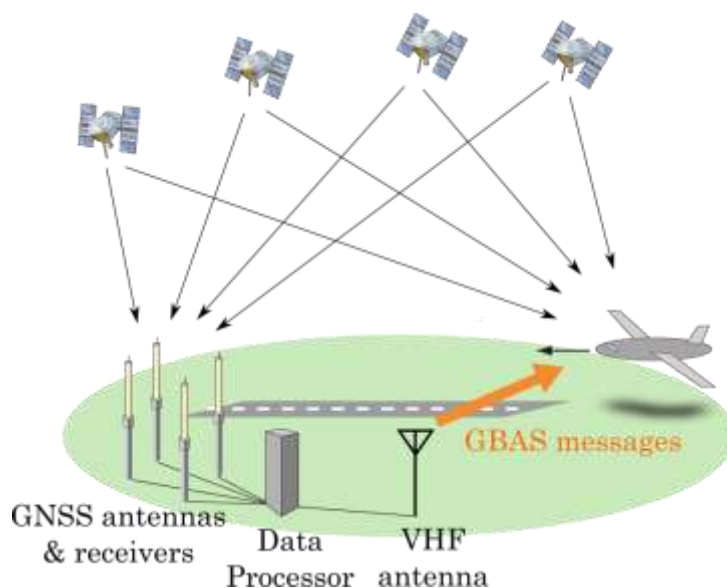


Figure 2. An example scenario of ionospheric delay anomaly for GBAS.

1.3. Ionospheric effects on GBAS

1.3.1. Propagation delay

In GBAS, the application of differential corrections by users almost completely removes ionospheric delay under nominal condition. However, range errors due to ionospheric delay can become significant if there is a large spatial gradient between ground station and user. If this gradient is large

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enough, it can create a large differential error (e.g., greater than 1 meter) in between the several kilometers separating the ground system and users. This error is increased through "carrier smoothing", where carrier-smoothed pseudorange is calculated using changes in the carrier-phase measurement to reduce the random noise in the code measurement [3]. This process increases ionospheric range error because the ionosphere delays code pseudo range, whereas it advances carrier phase. Because the absolute magnitudes of both effects are almost the same, ionospheric error almost doubles in carrier-smoothed code under steady-state conditions. Also, the "memory" in this filter extends the effective separation between ground station and user by a quantity roughly equal to the distance the user aircraft moves horizontally (toward the ground station) over two smoothing time constants. As mentioned above, the following equation gives us a typical magnitude of ionospheric range error δI in slant direction under steady-state conditions:

$$\delta I \cong \frac{dI}{dx}(x + 2\tau v)$$

, where x , dI/dx , τ and v are separation distance between aircraft and ground station along approach direction, ionospheric delay gradient, a time constant of carrier smoothing filter and aircraft velocity, respectively. For example, a large ionospheric delay gradient of 425 mm/km could produce a range error of about 8.5 meters in a case that a point of CAT-I decision height (DH) is 6 km away from GBAS ground station [2].

1.3.2. Scintillation effects

It is known that active ionosphere often causes scintillation effects which disturbs power and phase of GNSS signals. The strong scintillation sometimes causes loss of lock on GNSS signals from multiple satellites simultaneously. The GBAS is not a countermeasure against scintillation and users should be aware that availability and continuity of navigation may be degraded due to scintillation effects. A useful guidance is: 'Guidance material on scintillation measurements', ISTF/3-WP/9 [4].

2. Ionosphere conditions to consider for GBAS safety analysis

2.1. Overview of relationship between GBAS safety assessment and ionospheric conditions

GBAS protects users under "nominal" or "typical" ionosphere conditions by differential correction messages and an evaluation parameter for ionospheric error (σ_{iono}), which is derived from the broadcast parameter σ_{vig} (sigma vertical ionospheric gradient) and used to compute the vertical and lateral protection levels as defined in the ICAO Annex 10 Volume I [1] and RTCA LAAS MOPS, DO-253D Change 1 [5]. The protection level bounds the errors in the position solutions of the aircraft at the level of the integrity required for the corresponding operations. Therefore, anomalous ionosphere conditions are required to be accounted for in GBAS ground subsystem safety design. Anomalous conditions are those that spatial gradients generated are 6 times larger than the value of σ_{vig} after converting σ_{vig} from vertical (zenith) to slant gradients (i.e., multiplying by the satellite-elevation-

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dependent “obliquity factor” given by the RTCA LAAS MOPS, DO-253D Change 1 [5]). Under anomalous ionospheric conditions, positioning errors larger than the computed protection levels may occur, where these user-computed protection levels indicate upper bounds of user positioning error for lateral and vertical directions derived from evaluation parameters broadcast in GBAS messages [6][7]. To mitigate this ionospheric threat on GBAS, it is necessary to detect and exclude the affected ranging sources at GBAS ground stations or to adjust the parameters broadcast by GBAS to reflect possible anomalies. Therefore, it is important to evaluate both nominal and anomalous conditions for a safe system design against ionospheric effects.

2.2. Nominal conditions bounded by PL (protection level)

Regarding nominal conditions, the equatorial anomaly is a dominant factor in determining background ionospheric conditions in the low magnetic latitude region. Ionospheric delay dynamically changes during both day time and night time. It has seasonal variation, with spring and autumn being more active seasons. It also depends on solar activity, which has a cycle of about 11 years [8]. These effects should be covered by the parameter σ_{vig} broadcast by GBAS, although the details depend on the system safety design approaches. In general, σ_{vig} should be determined to bound a large population of observed data [9][10][11][12]. Note that an analysis limited to observational data collected during low solar activity period could lead underestimation of the appropriate value of σ_{vig} during more active periods.

2.3. Anomalous conditions and ionospheric disturbances to consider

2.3.1. Storm enhanced density

Storm Enhanced Density (SED) is an extreme ionospheric density enhancement associated with severe magnetic storms. It generally occurs in mid- to high latitude regions, and its occurrence rate is relatively rare in low latitude regions [13].

2.3.2. Plasma bubble

Plasma bubble phenomenon is another type of disturbance that can be summarized as a depletion (rather than enhancement) of ionospheric density relative to the surrounding environment. It has a structure spread along the North-South direction and can produce steep ionospheric spatial gradients and scintillation on GNSS signals [14][15][16]. It frequently occurs after sunset in high solar activity periods around the magnetic equator and further develops toward higher latitudes. In the Asia Pacific (APAC) region, its frequency of occurrence is highest during equinox seasons from March to April and from September to October. It is known that characteristics of plasma bubbles are different along longitudes. For example, plasma bubble activities in terms of the occurrence rate and the steepness of the slope are known to be high in South America [17]. However, they can be considered similar in longitude within the APAC region.

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2.3.3. Other

It is known that there are several phenomena with spatial ionospheric gradients such as TID (Traveling Ionospheric Disturbance) and disturbances in sporadic E layer. However, these phenomena do not produce significant effects on GBAS because of their variation amplitude including spatial scales.

2.4. Ionospheric threat model for GBAS safety analysis

An ionospheric threat model that includes all possible ionospheric anomaly conditions is required for a safe system design. An ideal threat model should mitigate most ionospheric effects on GBAS. Note that underestimation of the threat model bounds might expose users to unmitigated (and therefore unsafe) conditions, whereas overestimation of these bounds may degrade system availability. An Ionospheric front is a model with an ionospheric spatial gradient and is referred as wedge model [18]. The model enables us to perform quantitative analysis on range error impacted by ionospheric disturbances. Moreover, the model is required to find the worst case because an induced range error depends on not only ionospheric delay spatial gradient but also geometrical relationship among aircraft, ground station, ionospheric front and GNSS satellite path on equivalent ionospheric layer. The primary parameters of the ionospheric front model are summarized as four parameters, which are spatial gradient, front moving speed, width and drop. The last parameter means the maximum ionospheric delay difference of ionospheric front, and it is also given by combination of upper bounds for both spatial gradient and width [19]. Definition of the ionospheric front model is important to describe threat space for GBAS safe system design.

2.5. Evaluation of requirements and performance, including integrity monitoring

Because ICAO SARPs define safety requirements of integrity and continuity for GBAS ground subsystem together with accuracy and availability, it is important to evaluate ionospheric anomaly impacts on such requirements with the ionospheric threat model. For example, integrity requirement is defined to assure user's safety for any approach. In order to satisfy these requirements, it is required to implement appropriate mitigation methods for ionospheric anomaly if it causes Hazardous Misleading Information (HMI) for GBAS users. In general, integrity monitors to detect and exclude fault satellites are simple methods to mitigate ionospheric threats. However, it is notable that false alarm in the mitigation degrades continuity performance. Because integrity and continuity risks are not only ionospheric anomaly, it is required to allocate a targeted level for each risk through GBAS safety design to satisfy the requirements in total system. This risk allocation depends on each GBAS system including threat models for integrity risks. For issues on ionospheric anomaly, allocated target is converted to performance requirement for each integrity monitor in system design. Finally, total of remaining risk should be less than the targeted level.

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anomalous ionospheric conditions*

2.5.1. Ranging errors induced by ionospheric anomaly

Because estimated user's range errors are different among various scenarios with the four parameters, it is important to identify ranges for the four parameters to cover actual conditions with a certain safety margin and find the worst case scenario. Simulation analysis provides ranging errors induced by ionospheric anomaly using defined wedge model [6]. The simulation analysis should be conducted by different ways for GAST C [6][7] or D [20].

2.5.2. Positioning errors in the final implementation

Regarding CAT-I GBAS or GAST C, because ground subsystem has to evaluate not only user's ranging source errors but also their final positioning errors, it performs a kind of position domain monitoring in real time called geometry screening in addition to integrity monitors for ranging source anomalies [19][21][22]. Geometry screening is based on "potential" remaining ranging source error using the threat model and it validates various satellite geometry subsets which include impacted satellites. Since GBAS parameters are set against potential error based on threat model, the system availability also depends on threat model. To reduce potential remaining ranging source error, far field monitor is one of solutions [23]. For GAST D, this process is not necessary for the ground subsystem, because potential positioning errors are evaluated by the airborne subsystem by using the potential range error provided by the ground subsystem in the GBAS message dedicated for GAST D.

2.6. Other important descriptions

Except the four parameters of the ionospheric front model, there are some important parameters originated from characteristics of each ionospheric disturbance. For examples, locations, dominant season and/or time, occurrence rate and number of impacted satellites are key parameters. Using these characteristics, it is possible to construct threat models with certain flexibilities.

3. Development and validation of the threat model

The development and utilization of the ionospheric threat model occurs in two stages. The first stage is observation, in which data accumulated over a lengthy period is collected to describe and cover the features of ionospheric impacts on GBAS. The results of observation are used to estimate the bounding parameters of the threat model. The second stage is simulation, in which the completed threat model is used in a simulation of GBAS ground station and user operation. The user errors resulting from these simulations provide a basis for estimating the GBAS integrity risk and determining the impacts of changes to the ground and airborne monitors.

3.1. Observation stage

In the observation stage, networks of GNSS stations located close together (e.g., typically within 10 to 50 km) are needed. Each observation is based on the difference in ionospheric delays between two

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

nearby GNSS stations. In the case of dual frequency measurements for estimating ionospheric delay, inter-frequency biases must be corrected before ionospheric delay differences can be calculated.

It is well known that the error component of the estimated gradient increases in short baseline analysis because the gradient is calculated from difference of ionospheric delay divided by the baseline length (separation between stations) [9]. Moreover, where possible, the baseline length should be comparable with or smaller than the spatial scale of disturbances. Because SEDs are related to magnetic storms, data filtering based on indices caused by magnetic storms are useful for extraction of events, meaning identifying the times when large gradients are most likely to occur [18][24]. Plasma bubbles are created by different ionospheric mechanisms. Therefore, such index parameters are not enough to extract events, but local time filtering remains useful because plasma bubbles occur during local nighttime. Solar activity with a period of about 11 years is also an important factor for observation-based approach. To the degree possible, measurements should be taken near to the peak of this cycle (maximum solar activity) and in the several years following it, as the largest gradients are likely to occur during this period.

3.1.1. Tools like LTIAM (Long Term Ionospheric Anomaly Monitor)

It is important to construct database for safety analysis maintaining their compatibility and qualities through long term monitoring of ionospheric anomalies [24]. The LTIAM tool has been developed and used for the analysis [25]. The tool enables us to search events and extract important parameters for ionospheric threat mode. One of the advantages to use such a tool is to maintain the same quality for data process. Cross validation is also important issues and there is another evaluation tool based on Single Frequency Carrier Based Code-Added (SF-CBCA) measurement [26]. This tool requires only single frequency measurement data.

3.1.2. Time Step method

In general, ionospheric gradients are calculated from measurement data with a pair of station with appropriate baseline length to targeted ionospheric disturbances. However, time step method is also useful as an alternative method to station pair analysis especially for regions without dense GNSS networks with consideration on its characteristics [9].

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

3.1.3 Summary of how to develop the ionospheric threat model

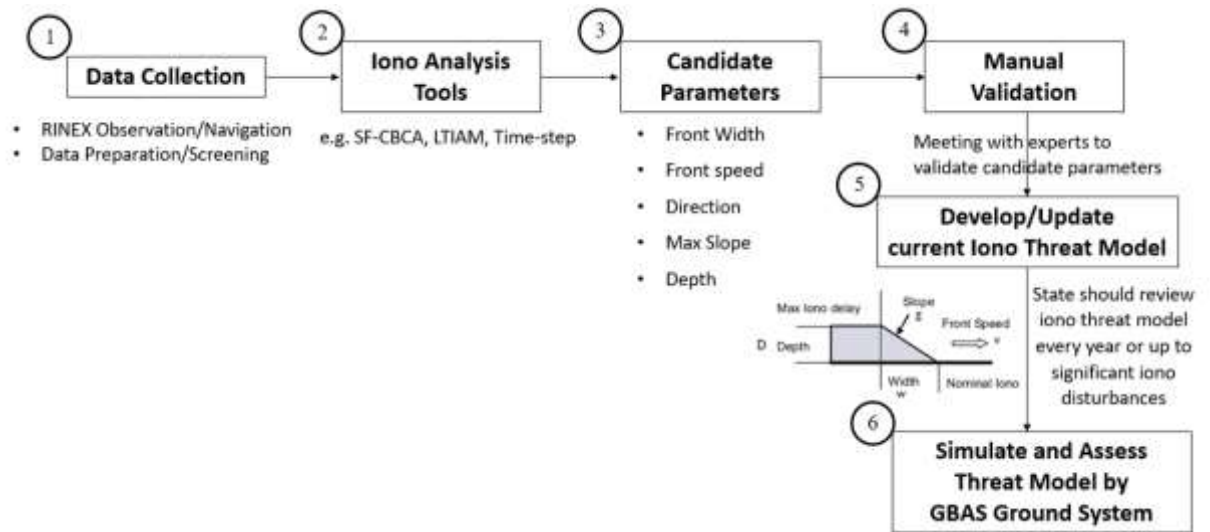


Figure 3. Steps for developing the ionospheric threat model.

Steps for evaluating ionospheric variability and developing the ionospheric threat model are summarized in Figure 3. Beginning with the step-1, the ionospheric threat model is developed with information from collected GNSS data in the area planned for implementation. To make data sharing and exchange easier, the GNSS data collected are recommended to be translated to RINEX (Receiver Independent Exchange Format) format, which is composed of both observation (*.**o) and navigation file (*.**n). The file name is recommended to follow the convention of RINEX which indicated the station identification and date of observation. For example, VTBS001.22o and VTBS001.22n are the observation and navigation file observed on 1 January 2022 at VTBS station. If timing of data collection is limited, focus of GNSS data should be given during equinox months, e.g., March, April, September and October during sunset and nighttime period since most ionospheric activity and plasma bubble mostly occur during these periods. Close attention should be given in the collection process since data is needed from all the receivers concerned, so faulty electric supply can cause missing data leading to inadequate information on a given day, or physical changes of the position of receivers can lead to incorrect judgement of gradient analysis. Moreover, if diverse types of receivers are used, make sure the data used for validation is of the same type and quality.

After adequate data is collected, there are various tools that could be used for the analysis in the step-2, e.g., LTIAM, SF-CBCA, and Time-Step method, which could be used to derive candidate parameters for the model, e.g., Front Width, Front Speed, Direction, Max Slope and Depth. For efficiency, since most parameters are derived from events with extreme ionospheric activity, collected data could be deduced first by techniques such as ROTI (Rate of TEC Change Index) to

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

isolate events of which data is to be analyzed. Once candidate parameters have been chosen, there is still the need to validate the chosen parameters by looking at the events that caused such values again in the step-4. It is satisfactory to use parameters resulting from such analysis tools, but to improve the model to match actual behavior, manual validation of individual events that may cause a worst-case scenario should be further analyzed. Since candidate parameters that result from ionosphere analysis tools sometimes come from an event of data jumping due to cycle-slip in a carrier phase measurement when the receiver loss of signal tracking, a meeting with the ionosphere experts and engineers is therefore conducted to confirm these candidate parameters. Once the ionosphere threat model has been developed, the model should then be used in an actual GBAS ground station to assess the operational limitations and availability as well as the integrity risk of the system. Since ionospheric activities mainly cause by a solar activity of each solar cycle, it is vital to monitor ionospheric activities continuously and regularly updated at least on an annual basis.

3.2. Simulation approach

In order to translate ionospheric threat model bounds into GBAS errors, simulations of GBAS ground station and user operations (e.g., airborne precision approaches) are required. In these simulations, the threat model is used to construct anomalous distributions of electron density according to the “front” or “wedge” model described in Section 2.6 above. As this front and approaching aircraft both move relative to the (static) ground station and the orbiting GNSS satellites, the impact of the ionospheric anomaly on ground measurements, user measurements, and ground and user monitor algorithms are recorded and evaluated. At the end of each approach simulation, the differential range and position errors along the approach can be evaluated with respect to the integrity requirements for that operation. If one or more monitors would have detected the anomalous ionospheric conditions prior to the occurrence of hazardous errors, those errors would have been mitigated by the exclusion of the affected GNSS satellite.

3.2.1. Three dimensional analysis

The ionospheric front model is based on two dimensional plan. However, actual distribution of electron density in ionosphere is more complicated. Therefore, it was pointed out that data analysis of SED with satellite signals from low elevation angle [27], simulation analysis concerning plasma bubble [28].

3.3. Validation

Threat model should cover observational and simulation results of the ionospheric delay gradient with appropriate safety margin.

3.4. GBAS ionospheric threat model for APAC region

The Ionospheric Studies Task Force (ISTF), which was established under the APANPIRG CNS Subgroup in 2012 and disbanded in 2016, collected ionospheric delay gradient data in the APAC

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

region and established the GBAS ionospheric threat model for APAC region [29][30]. It defines an conservative upper limit of the ionospheric delay gradient as 600 mm/km. This model can be used in the APAC region, though validation is necessary before actually used for individual GBAS implementation. The ICAO APAC GBAS ionospheric threat model defines only about the spatial gradient. Other parameters such as the front moving speed, width and drop are not defined in it, for which some studies have been made [31].

4. Post-implementation activities

Because safety management requires monitoring and improvement even after implementation, long term validation of ionospheric threat model has to be addressed. This means that additional observation data should be collected and analyzed over time after the establishment of the original threat model. Through this process, there are possibilities not only to find new ionospheric events outside the original threat model but also to reduce threat space with improved safety margin (e.g., if later observations suggest that the original bounds were too conservative). Solar cycles with different levels of maximum activity are also an important viewpoint, considering the fact that dense networks of GNSS continuous stations have only been deployed since the solar peak around 2000.

4.1. Monitoring of ionospheric activity

For long-term monitoring, it is important to consider solar cycle of about 11 years with consideration of characteristics of the targeted ionospheric disturbances. Additionally, information on occurred events are very important and useful for search similar events over neighboring area, i.e. such an event list gives candidate dates for the neighboring area.

4.2. Maintenance of threat model

There are two viewpoints. The first is to search new events which are not covered by the current threat model. The second is reconsideration of safety margin.

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anomalous ionospheric conditions*

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6. Annexes

6.1. CONUS model

CONUS model is described in [2].

*GBAS safety assessment guidance related to
anomalous ionospheric conditions*

6.2. Safety analysis for GBAS prototyping in Osaka

The ionospheric threat model is described in [32].

6.3. Other

Ionospheric threat model analysis is performed in such as [33].

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*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

Table of Contents

Chapter 1	Introduction	5
1.1	Background.....	5
1.2	Purpose and scope of this document	6
Chapter 2	Overview of GNSS	7
2.1	Overview of GNSS	7
2.2	Satellite-Based Augmentation System (SBAS).....	7
2.3	Integrity requirements and threats.....	10
Chapter 3	Threat Mitigation Strategy Against Anomalous Ionospheric Conditions.....	11
3.1	Ionospheric Characteristics	11
3.2	Definition of Nominal and Anomalous ionosphere	11
3.3	High level principles	12
3.4	Ionospheric correction by SBAS	13
3.5	Necessity of the threat model	14
3.6	Creation of the threat model.....	18
Chapter 4	Approval of SBAS.....	20
4.1	Approval: availability assessment.....	20
4.2	Evaluation of ionospheric conditions	21
4.3	Post-adoption activities	21
Appendix A	Ionosphere Algorithms for WAAS/MSAS/GAGAN	23
A.1	Standard planar fit.....	23
A.2	Ionosphere Estimation Algorithm Based on Kriging	24
A.3	Spatial threat model	25
A.4	Generation of spatial threat model	26
A.5	GAGAN MLDF Model	28

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

Chapter 1 Introduction

1.1 Background

1.1.1 GNSS is today widely used for civil aviation and GNSS-based operations with additional efficiency and flexibility are being implemented. A major advantage of GNSS, in comparison with conventional navaids, might be its accuracy and compactness; Users need only a small receiver set to have their accurate positions.

1.1.2 It is important to recognize that many error sources could affect GNSS. Among them, the ionosphere, existing at 300-400km above the ground, is a major error source which is not corrected enough by the GNSS core constellation. Invisible radio signals from GNSS space elements are affected by the ionosphere during propagation and thus have ranging delays.

1.1.3 A function of the augmentation system, including SBAS, is to provide users with better ionospheric corrections based on real time observation of ionosphere to improve position accuracy as well as availability of the system. Various ionosphere models, both theoretical and empirical, have been developed to provide information on ionospheric activities and ranging delays. Augmentation systems need to generate ionospheric corrections meeting integrity requirements.

1.1.4 The most important feature of an augmentation system for civil aviation is to provide position information with the integrity required for the intended operation. In other words, integrity is an essential element of an SBAS safety case, which must be met anytime and anywhere in the service area. A common application is the use by aircraft of GNSS-based vertical guidance to conduct RNP APCH operations down to LNAV/VNAV minima (LPV approach).

1.1.5 As per ICAO Document 9613 (PBN Manual), Part C, Chapter 5, Section B relating to RNP APCH operations down to LP and LPV minima, the State must verify that the augmented GNSS system and that the service provider of the GNSS system, used to support RNP APCH operations, are approved according to the appropriate regulation. ICAO Document 9849 (GNSS Manual), Section 1.5 also notes that by approving GNSS operations, a State accepts responsibility to ensure that such operations can be completed safely. Thus the responsible airspace authority should assess the integrity of the SBAS system in particular before its use by LPV procedures in the intended service area.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

1.1.6 In such an activity, ionosphere is a potential problem because its behavior depends upon many factors such as user location, local time, season of year, and solar activity. As a matter of fact, typical errors experienced due to anomalous ionospheric propagation can be 5-10 meters in vertical guidance, which constitute severe operational hazards particularly when they occur in the final approach segment. In this connection it is recognized by ICAO Doc 9613 that at some airports, it may not be possible to meet the requirements to publish an approach procedure with LPV vertical guidance. This may be due to the inability of SBAS to provide the desired availability of vertical guidance (i.e. an airport located on the fringe of the SBAS service area).

1.1.7 Generally an SBAS system should be validated to ensure that it meets ICAO Annex 10 requirements, including integrity requirements for operations within the airspace of the responsible airspace authority. The system may not meet those requirements outside the airspace. Therefore any previous activity conducted for another airspace may not be valid enough for the intended airspace. Considering that the Asia Pacific Region is diagnosed with a number of anomalous ionospheric phenomena, this activity should contain an evaluation of the magnitude of error due to irregularity of ionosphere.

1.1.8 Where there is no standardized process to assess the ionospheric error, the present document can provide further guidance.

1.2 Purpose and scope of this document

1.2.1 The purpose of this document is to provide guidance to evaluate ionospheric error in use of the currently deployed single-frequency(L1) SBAS as a part of integrity assessment. Differences from L1 SBAS from ionospheric effects perspective only have been incorporated. States might use information of this document for:

- (i) approval of SBAS system implemented by the State itself;
- (ii) approval of an SBAS service provider operating from another State; or
- (iii) assessment of GNSS SBAS vertical guidance availability.

1.2.2 Disclaimer. Note that this document gives guidance information only and is not a regulatory basis for approval of SBAS system or service provision.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

Chapter 2 Overview of GNSS

2.1 Overview of GNSS

2.1.1 As per ICAO Document 9849 (GNSS Manual), the concept of GNSS means the system consisting of core constellations, augmentation systems, and GNSS avionics (user receivers). Core constellation are GPS and GLONASS operated by the United States of America and the Russian Federation, respectively. Europe and China are developing systems (Galileo and the BeiDou Navigation Satellite System (BDS)) that will be interoperable with upgraded GPS and GLONASS.

2.1.2 Each core constellation has 24-32 ranging satellites orbiting around the Earth. Such ranging satellites are broadcasting radio signals for navigation use from the space. The typical altitude of the ranging satellites varies from 19,000 to 20,200 km above the ground.

2.1.3 The existing core constellations alone do not meet requirements of ICAO Annex 10 GNSS SARPS. To meet such requirements specific for aviation, core constellations need to be augmented in terms of accuracy and integrity of navigation.

2.1.4 Currently three augmentation systems are standardized by ICAO GNSS SARPS: aircraft-based augmentation system (ABAS), satellite-based augmentation system (SBAS), and ground-based augmentation system (GBAS).

2.1.5 ABAS achieves the required level of integrity only with onboard equipment, while the other two augmentation systems rely upon monitoring by the ground receivers. SBAS transmits augmentation information via geostationary satellite (GEO), while GBAS uses VHF data broadcast (VDB) for communication with user avionics.

2.2 Satellite-Based Augmentation System (SBAS)

2.2.1 Currently there are four SBAS systems in operation: US WAAS (Wide Area Augmentation System), Japanese MSAS (MTSAT-based Satellite Augmentation System), European EGNOS (European Geostationary Navigation Overlay Service), and Indian GAGAN (GPS Aided GEO Augmented Navigation). All of them are the single-frequency SBAS. All SBAS systems are continuously broadcasting augmentation information via GEO (geostationary satellite). Apart from them, presently, there are five SBAS systems under various stages of planning/development/deployment. These are – the System of Differential Correction and Monitoring

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

(SDCM) (Russia), the BeiDou SBAS (BDSBAS) (China), the Korea Augmentation Satellite System (KASS) (Republic of Korea), the SBAS for Africa and Indian Ocean (A-SBAS) which is renamed as Augmented Navigation for Africa (ANGA) (ASECNA) and the Southern Positioning Augmentation Network (SouthPAN) (Australia and New Zealand). BDSBAS has already published an interface control document (ICD) (<http://en.beidou.gov.cn/SYSTEMS/ICD/>).

2.2.2 The SBAS system monitors GPS signals by the network of ground stations. For radio signals transmitted from satellites in core constellations, the SBAS master station computes the ranging error and checks health status of signals. Based on the results, it generates correction and integrity information and broadcasts them on the SBAS signal via the uplink station.

2.2.3 The SBAS signal is broadcast at the center frequency of 1575.42MHz, same with GPS L1. The onboard avionics receives the SBAS signal via RF antenna and front-end circuit both common with GPS. However, some current SBAS GEOs broadcast additionally on 1176.45 MHz (L5) also which can be used as additional ranging source.

2.2.4 DFMC SBAS can improve robustness and navigation performance. The use of dual frequencies will help mitigate vulnerabilities in respect of ionospheric delay and delay variation caused by space weather and of radio frequency interference affecting a single frequency. While DFMC SBAS cannot correct for scintillation effects, the availability of multiple constellations will help to alleviate the risk of insufficient satellites which may be experienced with a single constellation. Aircraft equipped with DFMC GNSS receivers would be able to continue the intended operation during ionosphere events like plasma bubbles and ionospheric storms.

2.2.5 The SBAS signal can be received over the coverage area, but the service area is determined for each SBAS as a part of the coverage area. The performance of the SBAS is assured within the service area but might not for the whole of the coverage area.

2.2.6 The SBAS broadcast augmentation information for each ranging satellite per error sources, such as fast correction (FC), long-term correction (LTC), and ionospheric correction (IC) in case of the single-frequency SBAS. FC and LTC represent satellite clock and orbit errors and accompanied by the associated UDRE (user differential range error) parameter. IC consists of vertical delay for correction and GIVE (grid ionosphere vertical error) parameter representing the uncertainty of the correction. Additionally tropospheric correction (TC) is made inside user receivers by applying the tropospheric propagation error model.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

2.2.7 IC is given as a set of propagation delays, converted into vertical, at the IGP (ionospheric grid point). IGP is located with the interval of 5 degrees in latitude and longitude for low- and mid-latitude regions and with 10-degree interval at high-latitude regions. Users should apply the appropriate interpolation and vertical-to-slant conversion to broadcast IC in order to obtain the correction added to the measured range. Both interpolation and vertical-to-slant conversion procedures are defined in the GNSS SARPS.

2.2.8 The usage of IC (and GIVE) is mandatory for users in operations with vertical guidance, i.e., LNAV/VNAV and LPV operations, while it is optional for users in operations with horizontal navigation only. In fact, some SBAS systems are approved only for horizontal navigation.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

2.3 Integrity requirements and threats

2.3.1 The requirements in the GNSS SARPS is that the integrity risk is less than $2E-07$ in any approach for operations with vertical guidance, i.e., LPV (APV-I in the SARPS).

2.3.2 For the SBAS, the integrity function is implemented by the concept of protection level. The protection level means the upper bound of user position error with the specified integrity risk. The SBAS-capable avionics has capability to compute horizontal and vertical protection levels based on integrity information broadcast from the SBAS.

2.3.3 The integrity risk means the probability that either (or both) horizontal or vertical position error exceeds the associated protection level.

2.3.4 The horizontal and vertical alert limits are defined with dependency upon each operation mode. For SBAS-capable avionics, the integrity is assured by monitoring both horizontal and vertical protection levels are within the associated alert limit. For example, horizontal and vertical alert limits are 40 meters and 50 meters, respectively, for LPV approach mode.

2.3.5 In general, the protection level consists of two essential components: formal and threat terms. The formal term represents the uncertainty of corrections due to measurement noise which can be derived by covariance matrix for estimation. This term also covers nominal errors involved in clock and orbit information in the ephemeris data. The threat term represents the uncertainty due to rare events in non-nominal conditions.

This term is regarding faulty and anomalous events perhaps not observed yet.

2.3.6 Among all GNSS error sources, a non-nominal condition of ionosphere likely makes the largest threat for aviation use. The range error due to a fault of the onboard clock can be observed from all ground stations simultaneously and thus detected easily. For the satellite orbit error, non-nominal condition is not likely because GNSS satellites are orbiting under the law of physical dynamics. An exception is the maneuver for maintenance, but this can be predicted and detected by the network of the ground stations. In contrast, in the case of the ionosphere, the imperfection of the observability, because of limited density of the ground stations, causes the possibility of unpredicted variation of an ionospheric propagation delay due to small-scale spatial irregularities and temporal rapid changes of the status of ionosphere.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

Chapter 3 Threat Mitigation Strategy Against Anomalous Ionospheric Conditions

3.1 Ionospheric Characteristics

3.1.1 The Ionosphere is primarily dependent on Solar radiation i.e. the electron density will increase/decrease as solar activity increases/decreases. However, the distribution of electron density around Earth is controlled by various factors- Earth's Magnetic field and Electric field, Neutral winds and their density etc. Accordingly, the regions of ionospheric electron density distribution are divided or characterised, based on the location with respect to geomagnetic equator over Earth. In general, there are 3 ionospheric regions-

- (i) Equatorial and Low Latitude region ($0^\circ \pm 30^\circ$ Geomagnetic Latitude)
- (ii) Mid Latitude region ($30^\circ \pm 60^\circ$ Geomagnetic Latitude)
- (iii) High or Polar Latitude region ($60^\circ \pm 90^\circ$ Geomagnetic Latitude)

3.1.2 The Equatorial and Low latitude region is the most complex and dynamic of all ionospheric regions due to several phenomena operating over magnetic equator like Equatorial Ionization Anomaly (EIA) and Scintillations. Most of the Asia Pacific region lies in this ionospheric region and hence vulnerable to the ionospheric disturbances very often. The geomagnetic equator is approximately 8-9 degree offset in North to the geographic equator in Asia Pacific region and is not fixed.

3.2 Definition of Nominal and Anomalous ionosphere

3.2.1 Usually, the nominal and anomalous ionosphere is defined or identified by geomagnetic parameters – Kp and Dst index. These geomagnetic indices define the intensity of geomagnetic storms over the globe. The ionospheric response to the geomagnetic disturbances is well correlated over Mid and High Latitudes as they can induce the ionospheric disturbances like Storm Enhanced Density (SED).

3.2.2 The equatorial and low latitude ionosphere is, in general, anomalous in nature due to inherent characteristics of EIA. Moreover, the equatorial ionospheric response to magnetic storms can be positive or negative i.e. enhancement or reduction in electron density. In other words, during positive ionospheric storm, it can lead to enhanced EIA i.e. enhancement in electron density and/or shifting of Crest latitude farther away from equator. During negative ionospheric storm, the EIA can be weak, i.e. reduced electron density and/or shifting of Crest latitude towards equator; and even the complete absence of EIA i.e. crest formation at equator. Hence it is not realistic to correlate the anomalous ionospheric condition with global geomagnetic parameters (Kp, Dst) over Equatorial and low latitude

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

region.

3.2.3 Since equatorial and low latitude ionosphere is mostly governed by local/regional phenomena, the anomalous ionospheric conditions can be represented by localised ionospheric irregularity indicators like ROTI (Rate of change of TEC Index) and AATR (Along Arc TEC Rate). These are calculated using the GPS derived TEC measurements for the particular receiver. The Rate Of change of the TEC Index (ROTI) is one of the most widely used ionospheric indicators to characterize the ionospheric fluctuations [13]. It is considered as a proxy parameter of scintillation index - S4 and is useful in identifying the scintillation occurrence in absence of Scintillation monitoring receiver.

$$\text{Rate of TEC: } ROT = \frac{\Delta TEC}{\Delta t}$$

$$\text{Rate of TEC Index: } ROTI = \sqrt{\langle ROT^2 \rangle - \langle ROT \rangle^2}$$

where brackets ($\langle \rangle$) mean the ensemble average.

3.2.4 Similarly, AATR (Along Arc TEC Rate) was introduced and developed for EGNOS [14]. It was chosen as the metric to define the ionospheric operational conditions for the EGNOS. It was also adopted by ICAO APAC, ISTF for identifying the disturbed ionospheric conditions [ISTF/5, WP/06].

$$AATR_i = \frac{\Delta STEC_i}{(M(\epsilon))^2 \Delta T}$$

Where, i indicate the observation epoch; $\Delta STEC_i$ correspond to the difference of $STEC_s$ between two consecutive observations in the same satellite-receiver arc; ΔT is the elapsed time between these consecutive observations (typically 30 or 60 seconds); and $M(\epsilon)$ is the mapping function or obliquity factor to convert slant TEC to vertical TEC.

3.3 High level principles

3.3.1 Improvement of availability and continuity of the system. The protection level means the upper bound of navigation system error, with the significance level of $1E-07$, which reflects uncertainty of position information. The navigation system is available when both horizontal and vertical protection levels are less than the associated alert limits. This means that the reduction of protection levels is needed to improve the availability and continuity of the system.

3.3.2 The smaller the threat space, the better the performance. The protection levels are computed inside user receivers based on the parameters broadcast from the augmentation system. The broadcast integrity parameters provide information about uncertainty of corrections and are derived from two components: nominal uncertainty and margin for anomalous irregularity, i.e., the threat space. The former is associated with the Normal distribution and is not so large, while the latter is a

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

countermeasure against very rare events and constitutes the dominant component of the protection levels. Large threat space (inside SBAS ground facility) yields large protection levels (inside user equipment), thus degrades availability and continuity of the system. As a result, it is possible to improve performance of the system (availability and continuity) by employing a smaller threat space.

3.3.3 Usefulness in meeting integrity requirements is an essential characteristic of threat models. The Ionosphere Threat Model is used to meet SBAS integrity requirements. This means safety margin brought in to mitigate possibilities of ionospheric irregularities 'unobserved' (spatially and/or temporarily) from the ground stations. Each existing SBAS has its own ionosphere threat model to generate ionospheric correction information meeting integrity requirements. Each threat model should fit to its own service area. This document is concerned with the threat model for the Asia Pacific Region.

3.3.4 Schemes for ionosphere monitoring to protect airspace users. The behavior of the ionosphere is a natural phenomenon. Thus, the threat model once approved does not assure to over bound the anomalous ionospheric delays forever. This fact calls for an activity, ionosphere monitoring, to be conducted on a regular basis. The ionosphere monitoring shall be an activity similar to the creation of the threat model to confirm that the threat space is actually overbounding real ionospheric anomalies.

3.3.5 Scintillation effects. It is known that active ionosphere often causes scintillation effects, which disturb the received power and phase of GNSS signals. Strong scintillation sometimes causes loss of lock on GNSS signals from multiple satellites simultaneously. SBAS is not a countermeasure against scintillation, and users should be aware that availability and continuity of navigation may be degraded due to scintillation effects. Further information is provided in "Guidance Material on Scintillation Measurements," ISTF/3-WP/9 (Seoul, Korea, Oct. 2013). It should be noted that the scintillation effects would also affect the DFMC SBAS performance.

3.4 Ionospheric correction by SBAS

3.4.1 SBAS broadcasts information on ionospheric delay for correction. Vertical ionospheric delays on L1 carrier frequency at IGP are broadcast to users. They are accompanied by integrity parameters called GIVE representing uncertainty involved in the associated ionospheric correction. For each IGP, user receiver expects the vertical delay value on L1 and the associated GIVE index. The detail protocol of ionospheric correction and protection level computation is defined in the GNSS SARPS.

3.4.2 There are some methods for generation of ionospheric correction information inside SBAS.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

As an example, the algorithm of WAAS/MSAS, so-called ‘planar fit’ and ‘MLDF’ (Multi Layer Data Fusion) model used in GAGAN , is explained in Appendix A.1 and A.5, respectively.

3.4.3 The SBAS shall broadcast estimated ionospheric delay accompanied by the proper GIVE value regardless the ionospheric condition is nominal or non-nominal. This means that the GIVE value shall not be too small to ensure that both horizontal and vertical position errors never exceed the associated protection level, computed based on any combination of effective IC (and GIVE) information, for any users within the service area of the SBAS.

3.4.4 In other words, the GIVE parameter has to be computed with taking account of spatial and temporal threats, which are caused by local and/or short-term irregularities not sufficiently sampled by any ground station. SBAS must protect users against such irregularities.

3.4.5 Inside the SBAS system, in general, the GIVE value fundamentally involves the following terms:

- (i) The formal term due to the measurement noise of delay estimation;
- (ii) A term representing the threat of spatial variations; and
- (iii) A term representing the threat of temporal variations.

3.4.6 Term (i) is dependent upon the estimation methodology employed by the SBAS and the number of measurements made by the network of ground stations. A low-noise measurement environment contributes to the reduction of this term.

3.4.7 Term (iii) is derived from the largest rate of change of ionospheric delay. This term can be predicted well based on statistical analysis over the period of historical observations.

3.4.8 Among the three terms involved in the GIVE value, Term (ii) is the most difficult because the SBAS has to assume the existence of the largest ionospheric irregularities that might not be sampled by any ground station. Here the threat exists.

3.5 Necessity of the threat model

3.5.1 Overbounding uncertainty. The ionospheric vertical delay broadcast from the SBAS unfortunately contains some uncertainty because the estimation by the SBAS is not perfect and the thin shell ionosphere model cannot represent the real ionosphere completely. Thus, the ionospheric vertical delay at each IGP is accompanied by the associated GIVE parameter representing uncertainty

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

of estimation.

3.5.2 Even though the GIVE parameter is generated based on statistical processing along with the estimation of the associated vertical delay, there is some possibility, or risk, that the GIVE parameter does not overbound the actual error of the ionospheric vertical delay. This situation is called a ‘threat’.

3.5.3 Spatial and temporal threats. The ionosphere threat model is the actual function representing the associated threat space and is used to meet integrity requirements. This means adding safety margin to mitigate the possibility of the ionospheric irregularities being ‘unobserved’ (spatially and/or temporarily) by the ground stations, as illustrated in Figure 3-1.

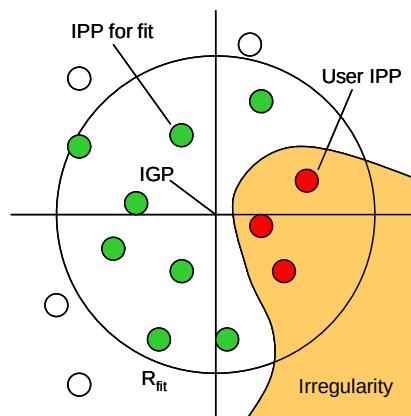


Figure 3-1: Schematic Diagram of Spatial Threat

3.5.4 Example of the spatial threat. In Figure 3-1, white and green plots represent ionospheric pierce points (IPPs) observed from ground stations of the SBAS, while Red plots represent IPPs observed from a user. Green IPPs inside the radius of R_{fit} centered at the IGP are used for the estimation of the status of the IGP. The problem is that the estimation does not reflect the irregularity coming from the right of the diagram, because no reference station observes the irregularity, while the user receiver shown in the figure does experience the irregularity. This situation may cause a large position error due to the irregularity observed by the user but unobserved by the ground stations.

3.5.5 An example of the spatial threat model is given in Appendix A.2. For generation of the spatial threat model, see Appendix A.3.

3.5.6 Operational Hazards related to the ionospheric threats. Operational Hazards or causes of operational hazards are identified as follows:

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

- (1) Mainly, the problem is spatial threats. The threat means local ionospheric irregularities observed by some users, but NOT observed by ground stations. Temporal threats may also be a problem, but we should be able to mitigate this kind of threat with enough archived data.
- (2) In general, ionospheric error roughly relates to vertical position error. In approach modes with vertical guidance, an incomplete ionospheric threat model may cause a safety hazard.
- (3) Integrity events of operational systems: so far, no integrity events due to ionosphere have been reported by operational SBAS systems. One can check integrity, e.g., if GIVE always overbounds the actual ionospheric error everywhere, using 'Triangle Charts' with the horizontal axis of ionospheric correction residual error divided by the obliquity factor and the vertical axis of 5.33 times σ_{GIVE} . Figure 3-2 shows an example of the triangle chart of ionospheric correction residual. If integrity is not met, i.e. there are any misleading information (MI), one can increase the magnitude of the threat model. A larger threat model provides more safety margin but results in less availability.
- (4) A concern may be 'Plasma Bubble' because, for example, the ionosphere model for some SBAS systems does not explicitly include information about plasma bubbles. It can be interpreted that the effects of plasma bubble events are implicitly bounded by the safety margin embedded in the ionospheric threat model, which might not be the case.

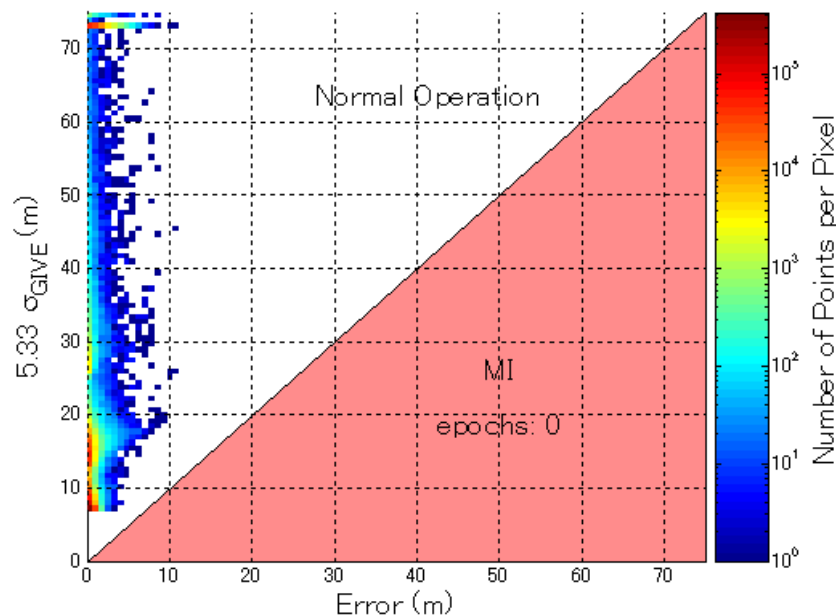


Figure 3-2: Example of Triangle Chart of Ionospheric Correction Residual.

3.5.7 Factors influencing the mitigation strategy. Factors influencing the mitigation strategy are identified as follows:

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

- (1) Observability of ionosphere: The mitigation strategy is influenced (or constrained) by:
 - The number and distribution of ground stations
 - The number of signal sources and the number of core constellations in use
 - The spatially dense observation of the ionosphere, which reduces the spatial threat by improving ionospheric observability
 - The availability of additional ground stations for generation of the threat model since the threat model might be refined if a larger network is available.
- (2) Relevance of the ionosphere model used for correction
 - An accurate ionosphere model (with enough observations) reduces the threat.
 - Geometry of the ionosphere model: Is the planar ionosphere model adequate for equatorial regions? What model could better represent equatorial anomalies?
- (3) Archive data available for creation of threat model
 - Basically, the threat model is created from the residuals of corrections (meaning the difference between the projected ionospheric delay as corrected by SBAS and the actual ionospheric delay observed separately) with regard to given algorithms and parameters for generation of SBAS ionosphere messages. To compute the residual of corrections, a separate archive of ionospheric delay data for a certain period, ideally a whole solar cycle, is necessary.
 - The quality of the threat model depends upon the period and region of the archive data used. More data makes the threat model more accurate.
 - While a general rule is difficult to establish, following examples of criteria can be useful.
 - The archive data should be long enough to cover at least one solar maximum period (meaning the peak of the 11-year solar cycle and several years on either side of the peak).
 - In the USA, data were collected from all GPS satellites on a continuous basis from a network of stations similar to the WAAS reference network.
 - In Japan, the threat model was established based on observations at 6 MSAS ground stations for some years, including the solar maximum in 2001. The observations contain storm days with a Kp index greater than 6 as well as nominal days.
 - In India, data from a network of 25 GAGAN-TEC stations, 15 GAGAN reference stations, and 2 IGS stations was selected to establish the threat model. The selected data includes stormy and nominal days over the period of 2004-2011.
 - There are some options in the number and density of stations used to generate the threat model.
 - A network of stations same or similar to the SBAS ground stations.
 - A network of stations greater than the SBAS ground stations. Dense network is useful to make the threat model accurate and reduce margins.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

(4) Implementation issues

- Some SBAS systems are already operational, while others are still in development.
- It should be considered if it is necessary to change the threat model with regard to its use in a specific region, even if the algorithm is the same. It should be noted always that the validity of the threat model is dependent upon the region to which it is applied.
- Also, the threat model is likely to be different for different SBAS ionospheric correction algorithms.

3.6 Creation of the threat model

3.6.1 The ionospheric threat model for the intended region might be created based on historical severe ionospheric storm data. The process should be:

- (i) Prepare enough archive data for a certain period for the intended region with dual frequency observations;
- (ii) Sort out periods of data that are expected to contain anomalous behavior based on indices of ionospheric and/or geomagnetic behavior, such as AATR, ROTI and/or Kp and Dst. For example, data in which the worst daily values of Kp greater than 6 and Dst were less than -200nT were selected as potentially anomalous in analyzing CONUS data for development of the GBAS threat model [8]. Since SBAS is more sensitive to anomalous ionospheric conditions than is GBAS, somewhat lower thresholds (e.g., worst daily $Kp > 5$ and $Dst < -100$) might be used for SBAS;
- (iii) Compute ionospheric delay measurements by removal of frequency-dependent biases;
- (iv) Generate SBAS ionospheric correction and GIVE values, in the form of Message Type 26, based on the SBAS MCS algorithm and parameters;
- (v) For the location of each ionospheric delay measurement, compute SBAS correction values based on the contents of Message Type 26 generated during this process;
- (vi) The difference between measurement and SBAS correction shows the actual error observed (For example, see Figure 3-2); and
- (vii) Accumulate the actual error and take the largest error as the threat - This accumulation might be performed with regard to the appropriate parameters used for generation of ionospheric corrections (Message Type 26), which means that the threat is modeled as a function of the parameters.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

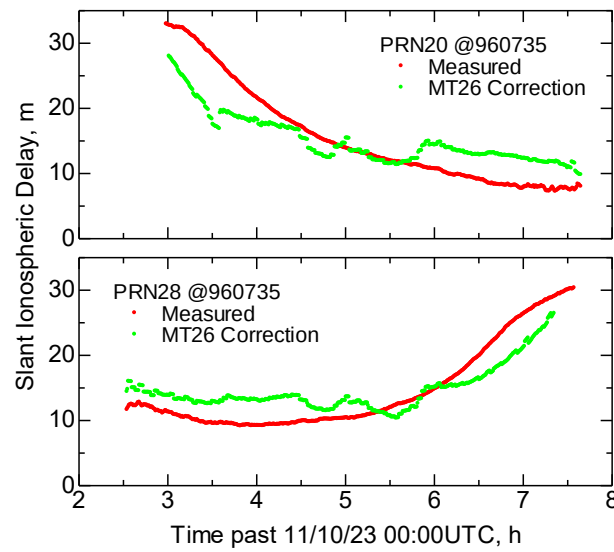


Figure 3-3: Example of Difference between Measurement and Correction

3.6.2 Necessity to archive data for a certain period: for how long? For this purpose, creation of threat model requires archive of GNSS data for a whole solar cycle (11 years), or at least during the latest peak of solar activity. A way to create the spatial threat model available for SBAS is 'data deprivation' (See Appendix A.3).

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

Chapter 4 Approval of SBAS

4.1 Approval: availability assessment

4.1.1 In general, the use of an augmentation system will involve a regulatory process of approval or safety assessment. This process is usually triggered by the introduction of new PBN procedures. The process should be conducted for the intended airspace and operations and include:

- (i) approval of SBAS system implemented by the State itself;
- (ii) approval of an SBAS service provider operating from another State; or
- (iii) assessment of GNSS SBAS vertical guidance availability.

4.1.2 The ANSP willing to enable the SBAS service within its FIR is responsible for construction of the safety case describing the system is safe for users against the certification by the regulator. The safety case should contain the explanation of the system architecture, conditions unsafe for users, the potential threats and mitigation including ionosphere. Operational issues such as the generation of NOTAMs and briefing material, and the training of controllers and technical personnel should also be addressed.

4.1.3 Regional Dependence. In the case of approval of an SBAS service provider operating from another State, the regulator shall note that the behavior of ionosphere in the Asia-Pacific Region may be different from the assumptions of the SBAS service provider. For example, the Japanese MSAS, operating with the threat model developed for Japanese airspace, should not automatically be approved for use in airspaces of other States unless the assumptions and the threat model of MSAS are validated and approved for the intended region of the operation.

4.1.4 Intended operations. In the case of non-precision approaches (NPA), ionosphere threat model assessment might not be required where no vertical guidance is provided. The proper mitigation of ionosphere anomalous conditions by the SBAS system should be assessed in cases where it serves for approach operations with vertical guidance, such as LPV, or with more stringent requirements.

4.1.5 Safety index. A tool to measure how much the integrity requirements are met, or how much the safety margin is expected for the intended operation, is so-called ‘safety index’. The safety index is defined as the ratio of the actual user position error to the associated alert limit. As an example, with sufficient margin to establish the integrity level of 10^{-7} , roughly speaking, the safety index for the LPV operations could be less than 5% in the nominal conditions while it could increase up to 10% or 20% in the non-nominal conditions.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

4.1.6 Assessment of GNSS SBAS vertical guidance availability. With the safety case for the intended airspace including the validated and approved assumptions and threat model, the system performance can finally be assessed by availability of the system for the intended operations. Typically the availability of non-precision horizontal navigation is almost 100%, while it is recommended to assess carefully if the availability of vertical guidance operations is sufficient for the intended operations or not.

4.2 Evaluation of ionospheric conditions

4.2.1 Because the behavior of ionosphere depends upon the region, the ionospheric threat model implemented inside the SBAS shall be evaluated for the intended region when the appropriate authority intends to approve it.

4.2.2 For this approval, the appropriate authority shall evaluate:

- (i) if the design of the algorithm of ionospheric correction and the ionospheric threat model is appropriate for the intended region;
- (ii) the characteristics of the ionospheric threat model using the real data.

The latter activity would be similar with creation of the threat model to confirm the threat space is actually over bounding real ionospheric anomalies.

4.3 Post-adoption activities

4.3.1 As explained at Section 3.3.4, the threat model once evaluated and confirmed does not assure to over bound the anomalous ionospheric delays for the future. Therefore, the ionosphere monitoring shall be performed on the regular basis after adoption of the SBAS.

4.3.2 The ionosphere monitoring shall be an activity similar to the creation of the threat model to confirm the threat space is actually overbounding real ionospheric anomalies. If an irregularity which may cause the integrity problem was found, the threat model should be updated for the region as needed.

4.3.3 Even in case it is difficult to perform the complete ionosphere monitoring, it is recommended at least to monitor the correlation between the safety index and solar activity. In case that the safety index often becomes larger than a certain threshold, for example 50%, during high solar activities, it is shown that the threat model employed in the SBAS may have some problem.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

4.3.4 Independent data sources for ionospheric monitoring: The ionospheric monitoring can be performed using data from either ground Reference station which is an integral part of SBAS system or from the independent stations having high-quality dual-frequency GNSS receiver. The data source from the independent stations provide an added advantage of capturing ‘unseen’ ionospheric activities by ground reference station, thus enabling the opportunity to monitor localized events like plasma bubbles or depletions. The examples of independent data sources are USA’s CORS network; JAPAN’s GEONET ; India’s GAGAN-TEC Network etc.

4.3.5 Depletion monitoring: The undetected Depletions or plasma bubbles are potential threat to any GNSS augmentation system and SBAS is no exception to that. During deep depletions, there is a potential risk that residual ionospheric delay is not bounded by the threat model. Hence, it is pertinent to monitor the depletion events using independent data sources which are spatially separated from ground reference stations. For SBAS perspective, the depth of the depletions or plasma bubbles is important parameter to monitor and note. The threat assessment shall be carried out during deep depletion events and in case of non-conformity of threat space, necessary update to threat model shall be done.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

Appendix A Ionosphere Algorithms for WAAS/MSAS/GAGAN

A.1 Standard planar fit

A.1.1 The WAAS (IOC version) and MSAS employs a so-called planar fit algorithm to generate ionospheric correction information. This algorithm is implemented in the operational system and run in real time with measurements from ground stations. Here we review the planar fit procedure explained in [1], [2] and reviewed in [3].

A.1.2 Using the thin shell ionosphere model, the vertical ionospheric delay ($\hat{I}_v$) around an IGP is modeled as:

$$\hat{I}_v(\Delta\lambda, \Delta\phi) = \hat{a}_0 + \hat{a}_1\Delta\lambda + \hat{a}_2\Delta\phi \quad (\text{A-1})$$

where $\Delta\lambda$ and $\Delta\phi$ are relative longitude and latitude from the location of the IGP, respectively.

A.1.3 Vertical ionospheric delay is estimated by the weighted least square method as:

$$[\hat{a}_0 \quad \hat{a}_1 \quad \hat{a}_2]^T = (G^T \cdot W \cdot G)^{-1} \cdot G^T \cdot W \cdot \mathbf{I}_{v,IPP} \quad (\text{A-2})$$

where G is an $N \times 3$ design matrix which describes the geometry of IPPs, and W^{-1} is the covariance matrix of the observation set, $\mathbf{I}_{v,IPP}$. $\hat{I}_{v,IGP} = \hat{a}_0$ is the resulting estimation.

A.1.4 Integrity is the most important requirement for SBAS, so the bounding information of corrected pseudorange is broadcast to users. For ionospheric corrections, the SBAS broadcasts a GIVE value for this purpose. The current algorithm computes GIVE values based, in part, on the formal variance of the least square fit.

A.1.5 The formal variance of the least squares fit of Eqn. (A-2) is given by:

$$\sigma_{I_v}^2(\Delta\lambda, \Delta\phi) = \begin{bmatrix} 1 \\ \Delta\lambda \\ \Delta\phi \end{bmatrix}^T \cdot [(G^T \cdot W \cdot G)^{-1}] \cdot \begin{bmatrix} 1 \\ \Delta\lambda \\ \Delta\phi \end{bmatrix}. \quad (\text{A-3})$$

A.1.6 Then the formal variance to bound uncertainty around the IGP is given by:

$$\sigma_{IGP_k}^2 = \max \left(\begin{matrix} \sigma_{I_v}^2(2.5, 2.5), & \sigma_{I_v}^2(-2.5, 2.5) \\ \sigma_{I_v}^2(2.5, -2.5), & \sigma_{I_v}^2(-2.5, -2.5) \end{matrix} \right). \quad (\text{A-4})$$

A.1.7 In case of SBAS, ionospheric information is broadcast on the grid points located every 5 degrees latitude and longitude, so each IGP takes care of threat region of 5 degrees square centered at itself.

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

A.1.8 The confidence bound with consideration of undersampled and temporal threat models is finally computed as [4]:

$$\sigma_{GIVE}^2 = R_{irreg}^2 \sigma_{IGP_k}^2 + \max(R_{irreg}^2 \sigma_{decorr}^2, \sigma_{undersampled}^2) + \sigma_{rate-of-chng}^2 \quad (A-5)$$

where $\sigma_{undersampled}^2$ denotes the undersampled threat, or spatial threat model, which is a function of geometry of IPPs relative to the corresponding IGP.

A.1.9 The term σ_{decorr}^2 denotes inherent uncertainty of the fit plane, and σ_{decorr}^2 is the so-called inflation factor as a function of the degree of freedom which is given by:

$$R_{irreg} = \sqrt{\frac{\chi_{1-PA}^2(n-3)}{\chi_{PM}^2(n-3)}}. \quad (A-6)$$

This factor is computed based on the chi-square statistics as a function of the degrees of freedom (the number of observations minus the number of unknowns).

A.2 Ionosphere Estimation Algorithm Based on Kriging

A.2.1 In WAAS Follow-On Release 3, the estimation of ionospheric delays is performed by an established, geo-statistical technique known as kriging. In addition to the standard planar fit algorithm, we also review the kriging based algorithm explained in [8][9].

A.2.2 The vertical ionospheric delay around an IGP is modeled in the same way as the standard planar fit, shown in Eqn. (A-1).

A.2.3 Vertical ionospheric delay is determined from a linear combination of known ionospheric delay measurements at IPPs near the IGP as

$$\hat{I}_{v,IGP} = \mathbf{w}^T \mathbf{I}_{v,IPP} \quad (A-7)$$

where $\mathbf{w}$ is the vector whose components include weight coefficients applied to the ionospheric delay measurements. $\hat{I}_{v,IGP}$ is the resulting estimation at the IGP.

The weight vector $\mathbf{w}$ is determined as

$$\mathbf{w} = [\mathbf{W} - \mathbf{W}\mathbf{G}(\mathbf{G}^T\mathbf{W}\mathbf{G})^{-1}\mathbf{G}^T\mathbf{W}]\mathbf{c} + \mathbf{W}\mathbf{G}(\mathbf{G}^T\mathbf{W}\mathbf{G})^{-1} \quad (A-8)$$

$$\mathbf{s} = [1 \quad \Delta\lambda \quad \Delta\phi] \quad (A-9)$$

where $\mathbf{G}$ is an $N \times 3$ design matrix which describes the geometry of IPPs, and $\mathbf{W}^{-1}$

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

is the covariance matrix of the observation set, $\mathbf{I}_{v,IPP}$. $\Delta\lambda$ and $\Delta\phi$ are relative longitude and latitude from the location of the IGP, respectively.

A.2.4 The formal error variance of the kriging estimate of Eqn. (A-7) is given by:

$$\sigma(\mathbf{w}) = R_{irreg}^2 [\mathbf{w}^T \mathbf{C} \mathbf{w} - 2 \mathbf{w}^T \mathbf{c} + c_0] + \mathbf{w}^T \mathbf{M} \mathbf{w} \quad (\text{A-10})$$

where R_{irreg} is the same inflation factor shown in Eqn. (A-6). $\mathbf{w}$ is the weight vector in Eqn. (A-7). $\mathbf{C}$ is the matrix describing the covariance between the ionospheric residuals from the planar trend and c_0 is the variance of the ionospheric residuals from the planar trend. $\mathbf{M}$ is the covariance of measurement noise between measurement locations. Note that Kriging effectively weights the contributions of vertical delays at IPPs near the IGP more heavily in the estimation than does the planar fit model by modeling the ionospheric covariance, $\mathbf{C}$, more accurately than the planar fit model.

A.2.5 The integrity bound, σ_{GIVE}^2 , is expressed formally as [8]:

$$\sigma_{GIVE}^2 \equiv \sigma_{IGP}^2 + \sigma_{undersampled}^2 \quad (\text{A-11})$$

where the term σ_{IGP}^2 is the formal error variance shown in Eqn. A-10, and $\sigma_{undersampled}^2$ is the same term as used in standard planar fit (Eqn. (A-5)).

A.3 Spatial threat model

A.3.1 One of the major concerns for SBAS is the potential error due to ionospheric irregularities which are not sampled by IPPs measured by the ground station network. The SBAS generates and broadcasts corrections and integrity information based on measurements of its own ground station network; However, some users might experience large error caused by unsampled ionospheric irregularities. This problem is called undersampling.

A.3.2 Figure A-1 explains such a condition. The planar fit estimates the vertical delay based on measurement IPPs within the radius of R_{fit} from the IGP, indicated by green circles. In this condition, the irregularity region is not sampled by monitor stations. However, some users have IPPs indicated by red circles in an irregularity region and would be exposed to a large error in the position solution. This is an undersampled threat condition.

A.3.3 In order to account this type of threat, WAAS and MSAS employ the ionospheric spatial threat model. The term $\sigma_{undersampled}^2$ in Eqn. (A-5) is determined by the threat model so that it ensures the

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

actual ionospheric error is always overbounded by the threat model for any users in the service volume.

A.3.4 For the MSAS (and IOC WAAS), the ionospheric spatial threat is characterized as a function of two metrics, i.e., the fit radius, R_{fit} , and the relative centroid metric, RCM computed as follows [5]:

$$\begin{bmatrix} 1 \\ d_{cent,x} \\ d_{cent,y} \end{bmatrix} = \frac{G^T \cdot W \cdot \mathbf{1}}{\mathbf{1}^T \cdot W \cdot \mathbf{1}}$$

$$RCM = \sqrt{d_{cent,x}^2 + d_{cent,y}^2} / R_{fit} \quad (A-12)$$

where i -th row of matrix G represents the geometric relationship between i -th IPP and the IGP.

$$G_i = [1 \quad \mathbf{d}_{IPPi} \cdot \mathbf{e}_E \quad \mathbf{d}_{IPPi} \cdot \mathbf{e}_N] \quad (A-13)$$

where $\mathbf{d}_{IPPi}$ is a vector to i -th IPP from the IGP, and $\mathbf{e}_E$ and $\mathbf{e}_N$ are unit vectors directing east and north from the IGP, respectively. The matrix W in Eqn. (A-12) is weighting matrix same to Eqn. (A-2). $\mathbf{d}_{cent} = [d_{cent,x} \quad d_{cent,y}]^T$ is the weighted centroid of IPPs for fit.

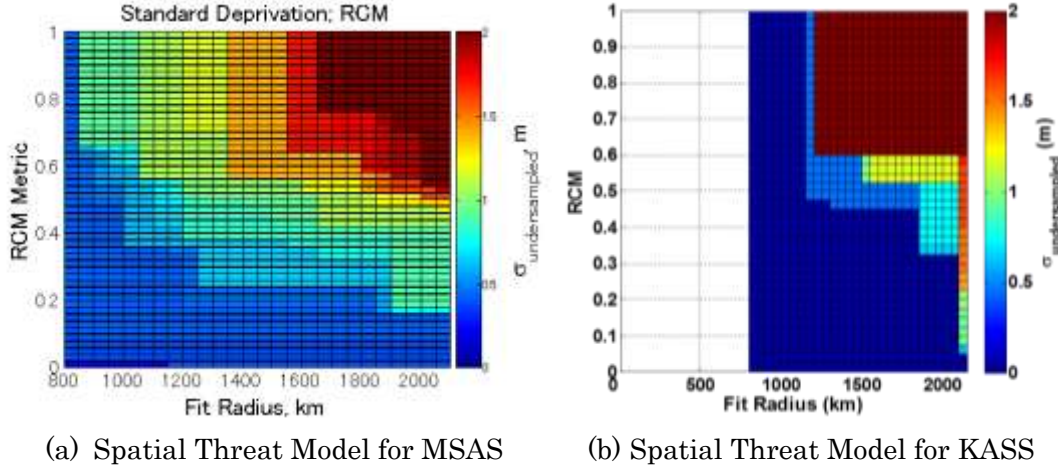


Figure A-1: Example of Spatial Threat Model

A.3.5 Figure A-1(a) shows an example of the ionosphere spatial threat model for MSAS using the observation dataset taken in Japan [6]. This example is similar with the operational version for MSAS.

A.3.6 An example of the ionospheric irregularity threat model for Korea Augmentation Satellite System (KASS) is shown in Figure A-1 (b). This model is an example which is developed using ionospheric storm data collected from reference stations in South Korea [11].

A.4 Generation of spatial threat model

A.4.1 The current threat model for MSAS was created by the data deprivation scheme [4]. In this

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

scheme, the set of IPPs observed at an epoch is divided into two sets, the set of measurements used for the fit and the set of virtual users. The planar fit algorithm is performed on the first set of measurements, and ionospheric delays at IPPs of the virtual user set are estimated from the second. Each residual between the planar fit estimate and a virtual user measurement provides a sample of possible error to which users are exposed.

A.4.2 The residuals are tabulated with respect to the threat model metrics, R_{fit} and RCM , and the largest residual contributes to the resulting threat model. The virtual user IPPs are defined within the threat region which is a 5 by 5 degrees square centered at an IGP, because in case of an SBAS, ionospheric information is broadcast on the grid points located every 5 degrees latitude and longitude.

A.4.3 Two schemes are used to create the threat model which covers the worst case under sampling condition. First, as shown in Figure A-2 (a), the annular deprivation scheme separates out data in successive annuli. In each iteration, measurements on an annulus (red plots) are not used for the fit and serve as virtual user measurements. The width of each annulus is set to 200 km and the inner radius of annuli changes from 0 to 2000 km. This scheme takes care of local irregularities and troughs of the ionosphere.

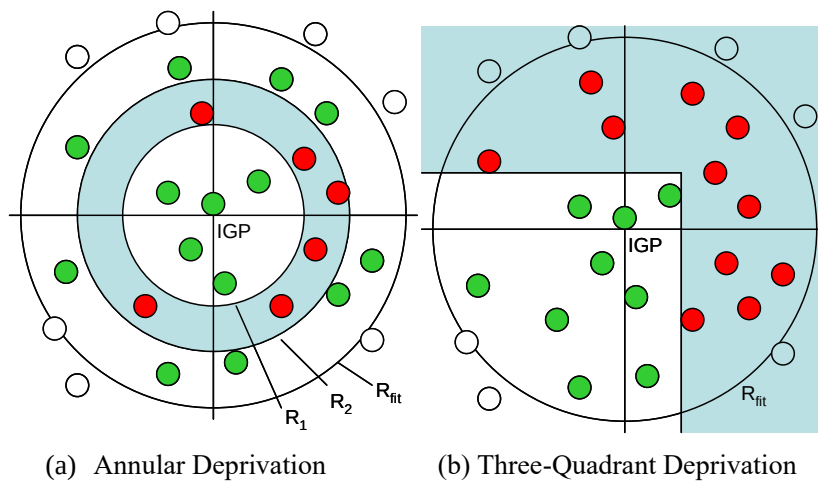


Figure A-2: Data Deprivation Schemes for the Threat Model

A.4.4 The second scheme is the three-quadrant deprivation illustrated in Figure A-2 (b). In this scheme, measurements in three quadrants are used as virtual user measurements and the planar fit algorithm is performed with IPPs in the remaining quadrant. The cutoffs are done at every 100 km within a 500 km range in four directions, so 44 iterations are performed for each IGP.

A.4.5 In addition to these two deprivation schemes, here called ‘standard deprivation,’ used to create

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

the current MSAS threat model, the malicious deprivation scheme has been developed [7]. This scheme provides the worst case undersampling condition with a lesser number of IPP removals. If the storm detector trips, the IPP with the largest residual from the plane is removed and set to be used as a virtual measurement, then planar fit is performed again. If storm detector trips again, the same process is repeated. The number of removed IPPs removed by this method is limited to no more than two for our study.

A.4.6 The last scheme of data deprivation is missing station deprivation [5]. In this scheme, measurements related to either a monitor station or a satellite are removed from the fit and used as virtual user measurements. This scheme provides conditions of loss of a station and decommissioning or outage of a satellite. Both are realistic for the actual operating system.

A.4.7 For the construction of the preliminary KASS ionospheric threat model shown in Figure A-1 (b), the missing station deprivation and the malicious deprivation are used. In addition to the missing station deprivation and the malicious deprivation scheme, the oversampling method developed for MSAS threat model [6] is applied to construct the ionospheric threat model. In the oversampling method, additional measurements observed from more than 60 GPS reference stations in South Korea are used to identify ionospheric irregularities that are not sampled by the KASS monitor stations [11].

A.4.8 Note that data deprivation provides two functions for creation of a threat model. At first, it derives possible conditions missing some IPPs for safety and conservativeness. Second, it provides IPP samples as virtual users to compute residuals and tabulate as a threat model.

A.5 GAGAN MLDF Model

A.5.1 Overview

A.5.1.1 The GAGAN employs a different approach to model the ionospheric delay, Multi Layer Data Fusion (MLDF) Model, in order to account for the vertical movement of ionosphere which is characteristic to the equatorial and low latitude region.

A.5.1.2 The MLDF Model is designed to capture the ionosphere variability at 2 different shell heights and provide a calculated value for the user at a 350 km shell height. The ionospheric delay and an error bound at 350 km is provided through “data fusion” technique in message type 26 [12].

A.5.1.3 The Threat model is required to ensure that the broadcast GIVEs have a sufficiently high level of integrity such that the User Ionosphere Vertical Errors (UIVEs) computed by user receivers will

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

bound their vertical ionosphere errors.

A.5.2 Assumptions

A.5.2.1 Ionosphere is assumed to be concentrated at two layers rather than one layer (due to typical equatorial ionosphere characteristics).

A.5.2.2 The distribution of the input noise and ionospheric delay residuals in the GIVE monitor are assumed to have near zero mean, symmetry, uni-modal and Cumulative Distribution Function (CDF) over bounding.

A.5.3 Features

A.5.3.1 The algorithm is designed on the new concept of computing Grid Ionospheric Vertical Delay (GIVD) at two different layers instead of a single thin shell so as to capture the large scale feature of the ionosphere.

A.5.3.2 Since the delays and confidences are finally transformed and fused to provide the GIVD, GIVE at 350km, this algorithm does not require any changes in the message structure (MOPS). The existing ionosphere messages in SBAS, i.e., message type 18 and 26, can be retained for ionosphere corrections.

A.5.3.3 The algorithm uses two different data sets for the kriging fit at individual layers. This ensures data independence while fusing the individual layer outputs.

A.5.4 Algorithm Description

A.5.4.1 The Grid Ionosphere Vertical Error (GIVE), consists of the fit error bound and threat models (Spatial, Temporal, Undersampled, Depletion and Storm detector inflation parameter). The GIVD at 350 km shell height is obtained by fusing the delays from two shell heights using data fusion. In the same manner, the fit error bound at 350 km is obtained by fusing the fit error bound from two shell heights using data fusion. The associated threat models are also computed at 350 km and the GIVE at 350 km is derived. Data fusion is performed only if required values are available for both lower and upper shell height. The fits at each shell height are performed using kriging estimation with geodetic latitude and longitude coordinate based variograms and ionospheric decorrelation models.

A.5.4.2 The steps involved in the MLDF algorithm are broadly described below:

- (i). Computation of pierce points at individual shell heights
- (ii). GIVD and fit Error bound at individual shell heights

*SBAS safety assessment guidance
related to anomalous ionospheric conditions*

- a. Ionosphere pierce point search algorithm
 - b. Computation of delay (GIVD) and fit error bound using a kriging fit
 - c. Goodness of fit (χ^2) and computation of inflation factor (R_{irreg}^2)
 - d. Computation of under sampling metrics from the fit
 - e. Computation of antenna bias error bound from the fit
- (iii). Data Fusion at 350 km
 - (iv). Computation of threat model at 350 km
 - (v). Computation of GIVE at 350 km

A.5.4.3 The schematic block diagram of MLDF algorithm is shown in Figure A.1

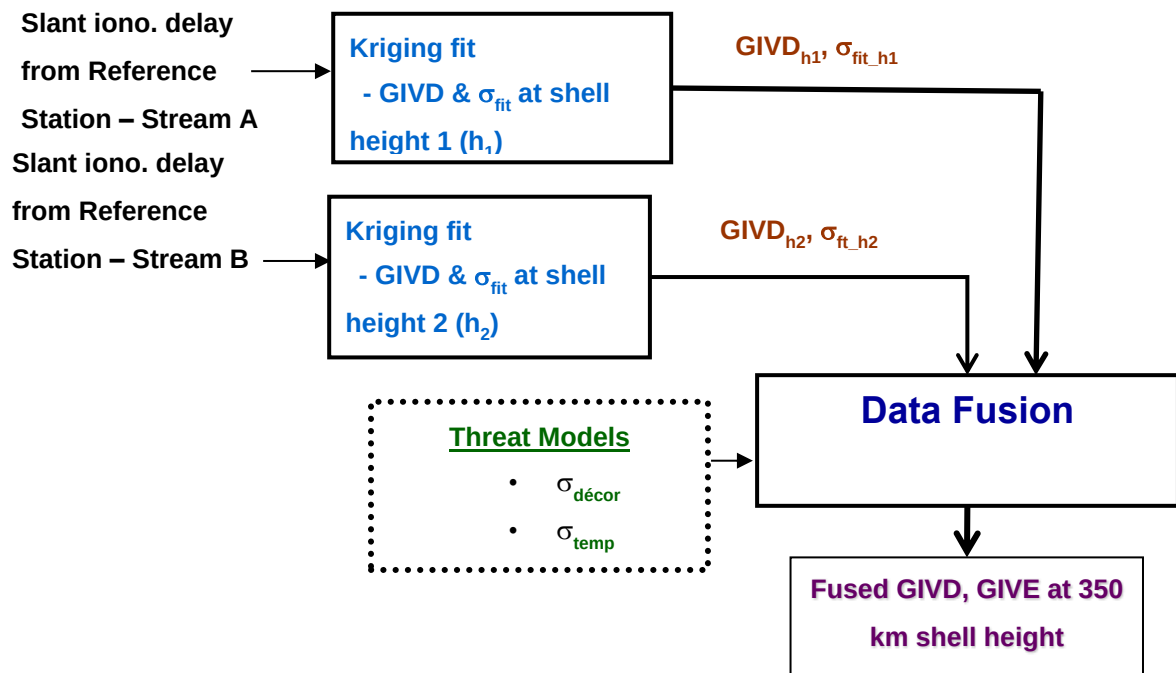


Figure A.3 : MLDF Algorithm – Block Diagram

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REVISED NAVIGATION STRATEGY FOR THE ASIA/PACIFIC REGION

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

1. The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

a) ~~Text to be deleted is shown with a line through it.~~	text to be deleted in
b) New text to be inserted is highlighted with grey shading.	new text to be inserted in
c) ~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

Considering:

a) ~~the material contained in the Performance Based Navigation Manual (Doc 9613) for enroute, approach, landing and departures operations;~~ Performance Based Navigation (PBN) as a means to support ICAO's strategic objectives of Safety and Air Navigation Capacity and Efficiency.

b) PBN implementation in Approach and Terminal area as one of the key ASBU elements to achieve capacity and efficiency.

c) ICAO Assembly resolution A37-11 on PBN Global Goals to implement PBN in all phases of flight.

d) the guidance/provisions contained in the Performance Based Navigation Manual (Doc 9613) for enroute, approach, landing and departures operations;

e) Operators are ~~qualified~~ certified for PBN operations as applicable;

f) GNSS is the primary navigation system for RNP;

g) APV operations may be conducted with either Baro-VNAV or ~~augmented GNSS~~ SBAS;

h) ~~Augmented GNSS is available to support Category I, and will be able to support Category II and III operations by 2018;~~ GBAS and SBAS are able to support Category I operation, and ICAO SARPs for GBAS to support up to Category II and III operations are available.

i) ~~ILS is capable of meeting the majority of requirements for precision approach and landing in the Asia Pacific Region~~ ILS is capable to support precision approach and landing including Cat II/III operations.

j) the need to maintain aircraft and ground interoperability both within the Region and between the Asia/Pacific Region and other ICAO regions and to provide flexibility for future aircraft equipage;

CNS SG/27
Appendix G to the Report

k) single-frequency GNSS may be susceptible to radio frequency interference and ionospheric disturbances and use of dual-frequency multi-constellation(DFMC) GNSS may mitigate risks caused by narrow band frequency interference and ionospheric disturbances.

j) ~~The region has developed an ionospheric threat model for GBAS.~~

Strategy

i) ~~Convert from traditional terrestrial-based instrument flight procedures to PBN operations in accordance with the Asia/Pacific Seamless ATM Plan.~~ Transition from traditional terrestrial-based instrument flight procedures to PBN operations in En-route, Terminal and Approach.

ii) ~~implement GNSS with augmentation as required for APV and precision approach or RNP operations where it is operationally and economically beneficial.~~ Implement APV operation with Baro-VNAV or SBAS(LPV).

iii) ~~implement SBAS/GBAS for precision approach Cat I and GBAS for Cat II/III where it is operationally and economically beneficial.~~

iv) ~~retain ILS as an ICAO standard system for as long as it is operationally acceptable and economically beneficial.~~ Retain ILS for precision approach especially for Cat II/III operations as long as it is operationally acceptable and economically beneficial.

v) rationalize terrestrial navigation aids, retaining a minimum network of terrestrial aids necessary to maintain safety of aircraft operations.

vi) protect all the Aeronautical Radio Navigation Service (ARNS) frequencies through education, appropriate regulation and the active detection and elimination of intentional and unintentional interference sources.

vii) ensure civil-military interoperability so that military aircraft is also capable of operation in PBN environment as far as practicable;

viii) continue monitoring the development of GNSS constellations and augmentations, including DFMC technology, and alternative position, navigation and timing;

ix) ~~strengthen protection on the ILS Critical and Sensitive Areas in three dimensional volumes in accordance with ICAO Annex 10.~~

GENERAL STRATEGY ON ASSIGNMENT OF AND MIGRATION TO SI CODE

Consider that when formulating the general strategy:

- a) It was previously shared that radars using SI code cannot detect II-only transponders unless a work-around known as the II/SI code operation is used;
- b) Even if a radar using SI code supports the II/SI code operation, it will not be able to detect an II-only transponder if that transponder is already locked to a matching II code by a radar using that matching II code. A way to overcome this is for II radars to also use the II/SI code operations whereby it will only lock out SI-capable transponders and not II-only transponders. However, it is difficult to ensure that all radars (including old radars) can support the II/SI code operations;
- c) Transponders that support only II codes are unlikely to disappear totally. Even with strict enforcement by ICAO, there will still be aircraft not subjected to ICAO's provision;
- d) While it is possible to configure the lock-out coverage to be smaller than the designated operating coverage, such configuration may not be intuitive and may be subjected to error;
- e) The European region is reserving II 14 and 15 (and their matching SI codes) for special use (i.e. research/test and military purposes);
- f) The Surveillance Panel is deliberating on a proposal to include a **requirement** for use of II/SI code operations for radars using SI code and a **recommendation** for the use of II/SI code operations for radars using II code; and
- g) The strategy is to be kept simple,

The following general strategy is thus proposed for the assignment of SI codes:

- a) ICAO APAC regional office will assign SSR Mode S II or Mode S SI codes in accordance with the planning criteria in *Appendix A-1*, at the same time ensuring support for Mode S II-only transponders;
- b) ICAO APAC regional office will only assign an SI code if the radar can support II/SI code operations;
- c) ICAO APAC regional office will only assign an SI code to radars having overlapping coverage with another radar using "matching" II code when the radar using "matching" II code can support II/SI code operations;
- d) The ICAO APAC Regional Office will assume that the designated operating coverage is the same as the lockout coverage. There will be a 5NM buffer between the coverages of two radars using the same II or SI code. States can, as necessary, select a lockout coverage that is smaller than the Designated Operational Coverage; and
- e) The ICAO APAC regional office will generally avoid assigning II 14 and 15 (and their matching SI codes) to new radars.

The following general strategy for migration is proposed:

- a) States with Mode S radars that can support II/SI code operation are encouraged to coordinate with the ICAO APAC Office to assign or re-assign SI codes to these radars.
- b) The ICAO APAC Regional Office may also approach certain States to start migrating to SI codes.

Appendix A-1

The following planning criteria for assigning SSR Mode S II or SSR Mode S SI codes have been agreed by the Surveillance Panel and will be incorporated in the ICAO Aeronautical Surveillance Manual (DOC 9924)

(Editorial Note: Some of the texts below are edited from the original material in DOC. 9924)

Table 1: Considered interrogator (interrogator for which an Interrogator Code is demanded) Mode S II-only interrogator Operating on II code Can operate with Mode S II-only and Mode S II/SI transponders				
Case	Capability of the overlapping interrogator	Operating code	Condition	Transponder Type
A	A Mode S II only	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
B	Mode S SI operating with II code (1)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
C	Mode S SI operating with SI code (1)	Any SI code, including a “matching” SI code	Overlap OK	II/SI
D	Mode S II/SI+ operating with II code (2)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
E	Mode S II/SI+ operating with SI code (2)	Non-matching SI code	Overlap OK	II-only and II/SI
		Matching SI code	No overlap	

Note 1: Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note 2: Mode S II/SI+ means Mode S II/SI capable interrogator which does support the II/SI code operation

Table 2: Considered interrogator (interrogator for which an Interrogator Code is demanded) Mode S II/SI interrogator that does not support the use of II/SI code operation. Operating on II code Can operate with Mode S II-only and Mode S II/SI transponders				
Case	Capability of the overlapping interrogator	Operating code	Condition	Transponder Type
A	A Mode S II only	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
B	Mode S SI operating with II code (1)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
C	Mode S SI operating with SI code (1)	Any SI code, including a “matching” SI code	Overlap OK	II/SI
D	Mode S II/SI+ operating with II code (2)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
E	Mode S II/SI+ operating with SI code (2)	Non-matching SI code	Overlap OK	II-only and II/SI
		Matching SI code	No overlap	

Note 1: Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note 2: Mode S II/SI+ means Mode S II/SI capable interrogator which does support the II/SI code operation

**Table 3: Considered interrogator (interrogator for which an Interrogator Code is demanded)
Mode S II/SI interrogator that does not support the use of II/SI code operation.**

Operating on SI code

Can only operate with Mode S II/SI transponders

Case	Capability of the overlapping interrogator	Operating code	Condition	Transponder Type
A	A Mode S II only	Any II code including the matching II code	Overlap OK	II/SI
B	Mode S SI operating with II code (1)	Any II code including the matching II code	Overlap OK	II/SI
C	Mode S SI operating with SI code (1)	Different SI code	Overlap OK	II/SI
		Same SI code	No overlap	
D	Mode S II/SI+ operating with II code (2)	Any II code including the matching II Code	Overlap OK	II/SI
E	Mode S II/SI+ operating with SI code (2)	Different SI code	Overlap OK	II/SI
		Same SI code	No overlap	

Note 1: Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note 2: Mode S II/SI+ means Mode S II/SI capable interrogator which does support the II/SI code operation

**Table 4: Considered interrogator (interrogator for which an Interrogator Code is demanded)
Mode S II/SI+ interrogator that supports the use of II/SI code operation.**

Operating on II code

Can operate with Mode S II-only and Mode S II/SI transponders

Case	Capability of the overlapping interrogator	Operating code	Condition	Transponder Type
A	A Mode S II only	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
B	Mode S SI operating with II code (1)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
C	Mode S SI operating with SI code (1)	Any SI code including a matching SI code	Overlap OK	II/SI
D	Mode S II/SI+ operating with II code (2)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
E	Mode S II/SI+ operating with SI code (2)	Any SI code including a matching SI code	Overlap OK	II-only and II/SI

Note 1: Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note 2: Mode S II/SI+ means Mode S II/SI capable interrogator which does support the II/SI code operation

**Table 5: Considered interrogator (interrogator for which an Interrogator Code is demanded)
Mode S II/SI+ interrogator that supports the use of II/SI code operation.
Operating on SI code**
Can operate with Mode S II-only and Mode S II/SI transponders

Case	Capability of the overlapping interrogator	Operating code	Condition	Transponder Type
A	A Mode S II only	Non-matching II code	Overlap OK	II-only and II/SI
		Matching II code	No overlap	
B	Mode S SI operating with II code (1)	Non-matching II code	Overlap OK	II-only and II/SI
		Matching II code	No overlap	
C	Mode S SI operating with SI code (1)	Different SI code	Overlap OK	II/SI
		Same SI code	No overlap	
D	Mode S II/SI+ operating with II code (2)	Any II code including a matching II code	Overlap OK	II-only and II/SI
E	Mode S II/SI+ operating with SI code (2)	Different SI code	Overlap OK	II-only and II/SI
		Same SI code	No overlap	

Note 1: Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note 2: Mode S II/SI+ means Mode S II/SI capable interrogator which does support the II/SI code operation

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Appendix I to the Report



**INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE**

**MODE S DOWNLINK AIRCRAFT PARAMETERS IMPLEMENTATION
AND OPERATIONS GUIDANCE DOCUMENT**

Edition 5.0 - March 2023

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PREFACE

This publication is one of the deliverables of the Mode S DAPs WG according to the Terms of Reference (TOR). It aims at providing guidance materials to States and airspace users on the use of Mode S DAPs in the Asia and Pacific Regions from both operational and technical perspectives. A working team was established to develop the contents, and China has volunteered to take lead on coordinating and consolidating inputs from members of the working team.

During Mode S DAPs WG/1 held in March 2018, the meeting considered that further development work is required before the initial draft (Edition 0.1) proposed by China and Hong Kong China becomes ready for approval. Then the working team began to develop the contents of the guidance document, China organized two internal conferences and ICAO APAC office organized a web conference for reviewing the contents. Based on numerous rounds of review and comments with joint efforts from the working team, China has revised the draft into five previous versions. Finally, Edition 1.0 was submitted for endorsement after Mode S DAPs WG/2, and published in the CNS SG/23. China revised the document and circulated it to the members of the Working Group for comments. Then Edition 2.0 was released in 2020, during CNS SG/24. Edition 3.0 was adopted by CNS SG/25 in 2021. Edition 4.0 includes information related to ADS-B DAPs, and was released in 2022, during CNS SG/26. The revised draft is prepared and proposed to be endorsed by Mode S DAPs WG/6.

The support from ICAO APAC Office and contributions from the following volunteer State/Administration and industry partner in preparing the guidance material is acknowledged and highly appreciated:

- Air Traffic Management Bureau of CAAC, China
- The Second Research Institute of CAAC, China
- Hong Kong Civil Aviation Department, China
- Civil Aviation Authority of Singapore
- Japan Civil Aviation Bureau
- Electronic Navigation Research Institute, Japan
- Airways, New Zealand
- Airservices, Australia

TABLE OF CONTENTS

1. INTRODUCTION	7
1.1 PURPOSE	7
1.2 BACKGROUND	7
1.2.1 Mode S and DAPs	7
1.2.2 Benefit of Mode S and Use of DAPs	8
1.3 ARRANGEMENT OF DAPS IGD	8
1.4 DOCUMENT HISTORY AND MANAGEMENT	9
1.5 COPIES	9
1.6 CHANGES TO DAPS IGD	9
1.7 EDITING CONVENTIONS	9
1.8 DAPS IGD REQUEST FOR CHANGE FORM	10
1.9 AMENDMENT RECORD	11
2. ACRONYMS LIST	13
3. REFERENCE DOCUMENTS	15
4. DESCRIPTION OF MODE S DAPS DATA	17
4.1 MODE S DOWNLINK FORMAT	17
4.2 MODE S ELS	18
4.3 MODE S EHS	19
4.4 ADS-B DAPS	20
4.5 THE DATA ITEM IN SSR DAPS AND ADS-B DAPS	21
4.6 DAPS DATA EXCHANGE PROTOCOL BETWEEN SURVEILLANCE AND ATM AUTOMATION SYSTEM	22
5. IMPLEMENTATION PRINCIPLES AND PHASES	24
5.1 IMPLEMENTATION PRINCIPLES	24
5.1.1 Stakeholders Coordination	24
5.1.2 System Compatibility	24
5.1.3 DAPs Data Integrity	25
5.1.4 System Integration	25
5.2 IMPLEMENTATION CHECKLIST	26
5.2.1 Activity Sequence	26
5.2.2 Concept Phase	26
5.2.3 Design Phase	27
5.2.4 Implementation Phase	28
6. SYSTEM INTEGRITY AND MONITORING	29
6.1 INTRODUCTION	29
6.2 PERSONNEL LICENSING AND TRAINING	29
6.3 ATS SYSTEM VALIDATION	29
6.3.1 Safety Assessment Guidelines	29
6.3.2 System Safety Assessment	29
6.3.3 Integration Test	30

6.3.4	ATS Operation Manuals	30
6.4	SYSTEM MONITORING	30
6.4.1	Consideration for System Monitoring.....	30
6.4.2	Mode S DAPs Problem Reports	31
6.4.3	Example of Mode S DAPs Problem	32
6.5	APPLICATION ANALYSIS.....	32
6.5.1	Data Recording.....	33
6.5.2	Local Data Collection.....	33
6.5.3	Avionics Problem Identification and Correction.....	33
6.6	IDENTIFIED ISSUES	33
7.	REGULATIONS AND PROCEDURES.....	34
7.1	MANDATING MODE S DAPS	34
7.2	AVIONICS.....	35
7.2.1	Mode S Transponder Capabilities	35
7.2.2	Mode S Transponder Mandate.....	37
7.2.3	Transition Guidelines.....	37
7.2.4	Mode S Transponder Working on the Ground.....	38
7.2.5	1090MHz Extended Squitter Transponder capability.....	38
7.3	EXTRACT MODE S SSR DAPS USING A MODE S INTERROGATOR	40
7.3.1	Working Principles	40
7.3.2	Interrogator Codes	40
7.3.3	Mode Interlace Pattern.....	41
7.3.4	Mode S SSR DAPs Extraction using GICB Protocol	41
7.3.5	Mode S SSR DAPs Extraction using AICB Protocol.....	43
7.3.6	Mode S SSR DAPs Extraction using Comm-B Broadcast.....	43
7.3.7	Error Protection.....	44
7.4	PROVISION OF ADS-B DAPS USING EXTENDED SQUITTER.....	44
7.4.1	Working Principles	44
7.4.2	ADS-B Message content.....	45
7.4.3	ADS-B message Transmission Broadcast rate.....	47
7.5	APPLICATION OF THE MODE S DAPS IN ATM AUTOMATION SYSTEM.....	49
7.5.1.	Implementation of the General DAPs information	49
7.5.2.	Mode S SSR DAPs	51
7.5.3.	ADS-B DAPs.....	52
7.6	FLIGHT PLANNING	53
7.6.1	ICAO Flight Plan Item 7 - Aircraft Identification.....	53
7.6.2	Equipment (Surveillance Equipment /SSR Equipment).....	53
7.6.3	Inconsistency between Mode S Flight Planning and Surveillance Capability.....	54
7.6.4	Setting Flight ID in Cockpits	55
7.7	CONTINGENCY PLAN.....	55
8.	TRAINING AND COMPETENCY	56
8.1	INTRODUCTION.....	56
8.2	TRAINING OF AN AIR TRAFFIC CONTROLLER (ATC) IN DAPS	56

8.3	TRAINING OF AN ATSEP IN DAPS	56
8.4	COMPETENCY ASSESSMENT OF AN ATSEP IN DAPS	57
9.	SPECIFIC EXAMPLES ON MODE S DAPS APPLICATION	58
9.1	USE OF SELECTED ALTITUDE.....	58
9.2	USE OF ACAS RA	58
9.3	USE OF MODE-S DAPS DATA FOR WEATHER FORECAST	59
9.4	USE OF BAROMETRIC PRESSURE SETTING	59
9.5	APPLICATION OF GEOMETRIC HEIGHT OF ADS-B IN ANALYSIS OF HEIGHT-KEEPING-PERFORMANCE IN RVSM	60
9.6	USE OF ADS-B DAPS FOR GPS INTERFERENCE IDENTIFICATION	61
	APPENDIX 1: MODE S DAPS ANALYSIS	63
	APPENDIX 2: LIST OF IDENTIFIED ISSUES.....	67
	APPENDIX 3: A BRIEF INTRODUCTION OF MODE S SSR DAPS DATA SOURCE	73
	APPENDIX 4: MODE S PARAMETER SET	81
	APPENDIX 5: RADIO FREQUENCY (RF) MEASUREMENTS AND ANALYSIS	87

1. INTRODUCTION

1.1 Purpose

This Mode S Downlink Aircraft Parameters Implementation and Operations Guidance Document (DAPs IGD) provides guidance for the planning, implementation and operational application of Mode S DAPs technology in the Asia and Pacific Regions.

The procedures and requirements for Mode S DAPs operations are detailed in the relevant States' AIP. This IGD is intended to provide key information on Mode S DAPs performance, integration, principles, procedures and collaboration mechanisms.

The content is based upon the work to date of the Mode S DAPs Working Group and various ANC Panels for the operational use of Mode S DAPs.

1.2 Background

1.2.1 Mode S and DAPs

Mode S (Select) is an extension of conventional SSR which permits selective addressing of individual aircraft equipped with Mode S transponders. Additional data known as Downlink Aircraft Parameters (DAPs) may also be extracted from the aircraft, including aircraft identification which should correspond to the ACID entered in the flight plan.

Mode S operates on the same radio frequencies (1030 and 1090 MHz) as conventional SSR systems, allowing for interrogation of Mode A/C only transponders and Mode S transponders.

Each Mode S equipped aircraft is assigned a unique ICAO 24-bit aircraft address. Using the selective interrogation capability of the Mode S SSR, Mode S Sensors are able to first acquire and then selectively interrogate a specific aircraft via its unique ICAO 24-bit aircraft address. This significantly improves the radar's detection and tracking performance, and therefore improving the ability of ATC to monitor and control the aircraft, as well as the others around it.

The innovation of Mode S resides in the use of selective addressing of aircraft which offers technical advantages over conventional SSR, such as reducing "fruit" and "garbling", providing higher integrity radar tracks.

Mode S technology has the following characteristics:

- a) selective interrogation,
- b) individual aircraft address and
- c) datalink capability.

The Mode S application includes Mode S radar system, datalink Systems, MLAT Systems, etc.

Various avionics systems onboard an aircraft receive data from sensors to provide the DAPs output. The data mainly comes from several sets of sensors, such as air data sensors (including pitot probe, static port, temperature sensor, and angle of attack sensor), inertial sensors (including position gyroscopes, rate gyroscopes and accelerometers) and magnetic sensor(s). Part of the parameters produced by other avionics systems (such as MCP/FCU, FMS, TCAS, etc.) are also defined as downlink aircraft parameters. These

parameters are then sent to the transponder through standard data buses, and stored inside the relevant transponder's 256 different 56-bit wide Binary Data Store. Ground-based surveillance systems (such as MSSR or MLAT) can downlink the desired parameters using specific Mode S protocols.

For detailed information about DAPs data source, please refer to Appendix 3.

Mode S DAPs is an application of the Mode S Datalink System. The downlink standard length transaction interface shall deliver DAPs to the transponder which then makes data available to the ground surveillance systems. Each DAP shall be packed and then transmitted by the downlink SLM, ground-initiated and broadcast protocols.

There are 255 Comm-B registers within the Mode S transponder, some of them are assigned for Mode S SSR DAPs and some are assigned for ADS-B DAPs. The Mode S transponder transmits extended squitter to support the ADS-B message transmitted on 1090 MHz which is called ADS-B DAPs. And the SSR DAPs can be extracted using either the ground-initiated Comm-B (GICB) protocol, or using MSP downlink channel 3 via the data flash application.

There are four 1090 MHz Extended Squitter ADS-B MOPS versions with the latest, Version 3 published in December 2020. With each new version, some messages have different formats and contain additional or eliminated message subfields. As version 3 is so new there are few if any avionics which meet the standards, therefore the related information of ADS-B DAPs in this document is based on the version 2 and earlier versions.

1.2.2 Benefit of Mode S and Use of DAPs

The Mode S application reduces the weakness of Mode A/C, because of the selective interrogation reducing synchronous garble and asynchronous interference. The parity check technique improves the reliability and integrity of surveillance data. The availability of almost 17 million unique aircraft addresses, in conjunction with the automatic reporting of flight identity, alleviates Mode 3/A code shortages and enables unambiguous aircraft identification, if the correct aircraft address and/or Aircraft Identification are entered in both the flight plan and aircraft systems. The datalink technique assists the acquisition of downlink aircraft parameters, and the additional track label information improves the air situational awareness. The controller and pilot are presented with improved situation awareness, which reduces the R/T workload.

Another benefit is to maximize SSR Mode 3/A code savings. By introducing the Mode S Conspicuity Code, all aircraft identified by Mode S via DAPs (ACID) can use the same SSR Mode 3/A code. During the 6th meeting of ATM SG, the following Conclusion is adopted:

Conclusion ATM/SG/6-3: Proposed Air Navigation Plan Volume II Amendment

'A1000' was reserved for the Mode S Conspicuity Code for the ICAO APAC region.

The ADS-B DAPs also provide benefits such as economical, enhanced safety and efficiency. The position report in ADS-B message is transmitted with an indication of the integrity associated with the data. And the ADS-B ground station is simpler than the stations of primary radar, secondary radar and multilateration, and acquisition and installation costs are significantly lower. Since ADS-B messages are broadcast, it supports both ground-based and airborne surveillance applications.

1.3 Arrangement of DAPs IGD

The Mode S DAPs Implementation and Operations Guidance Document consists of the following parts:

Section 1	Introduction
Section 2	Acronym Lists
Section 3	Reference Documents
Section 4	Description of Mode S DAPs Data
Section 5	Implementation Principles and Phase
Section 6	System Integrity and Monitoring
Section 7	Regulations and Procedures
Section 8	Training and Competence
Section 9	Specific Examples on Mode S DAPs Applications

1.4 Document History and Management

The framework of this document was introduced in the first Working Group Meeting of Mode S Downlink Aircraft Parameters in March 2018. The Meeting agreed to further develop based on the proposed framework to a complete document for approval as a regional guidance document. A working team, consisting of volunteers from China, Hong Kong-China, Japan, Malaysia, Singapore, Thailand and New Zealand was established by the Meeting to contribute to the content of the document. In July 2018, the completed draft of this document was ready for circulation among States for review and comment.

The aim of this document to supplement SARPs, PANS and relevant provisions contained in ICAO documentation, and it will be regularly updated to reflect evolving provisions.

1.5 Copies

Paper copies of this DAPs IGD are not distributed. Controlled and endorsed copies can be found at the following website: <http://www.icao.int/APAC/Pages/edocs.aspx> and may be freely downloaded from the website, or by emailing APANPIRG through the ICAO Asia and Pacific Regional Office who will send a copy by return email.

1.6 Changes to DAPs IGD

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (see Section 1.8 below) should be completed and submitted to the ICAO Asia and Pacific Regional Office. The Regional Office will collate RFCs for consideration by the Surveillance Implementation Coordination Group.

When an amendment has been adopted by the meeting of the Surveillance Implementation Coordination Group, then a new version of the DAPs IGD will be prepared, with the changes marked by an “|” in the margin, and an endnote indicating the relevant RFC, so a reader can see the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted, e.g.:

Final approval for publication of an amendment to the DAPs IGD will be the responsibility of APANPIRG.

1.7 Editing Conventions

(Intentionally blank)

1.8 DAPs IGD Request for Change Form

RFC Nr:	

Please use this form when requesting a change to any part of this DAPs IGD. This form may be photocopied as required, emailed, faxed or e-mailed to ICAO Asia and Pacific Regional Office +66 (2) 537-8199 or APAC@icao.int

1. SUBJECT:			
2. REASON FOR CHANGE:			
3. DESCRIPTION OF PROPOSAL: [expand / attach additional pages if necessary]			
4. REFERENCE(S):			
5. PERSON INITIATING:		DATE:	
ORGANISATION:			
TEL/FAX/E-MAIL:			
6. CONSULTATION RESPONSE DUE BY DATE:			
	Organization	Name	Agree/Disagree
			Date
7. ACTION REQUIRED :		DATE REC'D :	
8. DAPs IGD EDITOR		DATE :	
9. FEEDBACK PASSED			

1.9 Amendment Record

Amendment Number	Date	Amended by	Comments
0.1	20 March 2018	China Hong Kong, China	Initial draft for consideration by Mode S DAPs WG/1
0.2	1 August 2018	China Hong Kong, China Japan Singapore Malaysia	First completed draft based on the agreed document framework in Mode S DAPs WG/1 for review and comment by States
0.3	23 August 2018	China	Based on Version 0.2 draft, China hold a meeting to discuss problems respecting the first completed draft. This is a revised document according to content of this meeting.
0.3.1	26 September 2018	China Hong Kong, China Singapore New Zealand	Based on Version 0.3 draft, States make a full comment on the content of IGD. This is a revised document according to those comments.
0.3.2	6 November 2018	China New Zealand Hong Kong, China Singapore Malaysia	Based on Version 0.3.1 draft, States discussed all comments of IGD in the Mode S DAPs WG 1st Web Conference. This is revised by the meeting decisions.
0.4	27 December 2018	China New Zealand Singapore Australia	Based on Version 0.3.2, States review and comment on the IGD. This is a revised document according to those comments.
1.0	14 March 2019	China Japan Singapore Malaysia	Consideration by Mode S DAPs WG/2
1.1	17 February 2020	China New Zealand Singapore	Modify based on Version 1.0, States review and comment on the IGD.
2.0	13 May 2020	China	Consideration by Mode S DAPs WG/3
3.0	March 2021	China	Consideration by Mode S DAPs WG/4
4.0	March 2022	China	Add information related to ADS-B DAPs and guidance on measurement of 1030/1090 MHz usage

5.0	March 2023	China	

2. ACRONYMS LIST

AA	Aircraft Address
AAD	Assigned Altitude Deviation
AC	Altitude Code
ACAS	Airborne Collision Avoidance System
ACID	Aircraft Identification
ADS-B	Automatic Dependent Surveillance-Broadcast
AICB	Air-Initiated Comm-B
AIGD	ADS-B Implementation and Operations Guidance Document
AIP	Aeronautical Information Publication
AMC	Acceptable Means of Compliance
ANC	Air Navigation Conference
ANSP	Air Navigation Service Provider
APAC	Asia Pacific
ASE	Altimetry System Error
ASTERIX	All Purpose Structured EUROCONTROL Surveillance Information Exchange
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Service
ATSEP	Air Traffic Safety Electronic Personnel
BDS	Comm-B Data Selector
CA	Capability
CDTI	Cockpit Display Traffic Information
CFL	Cleared Flight Level
CLAM	Cleared Level Adherence Monitoring
CNS	Communications, Navigation and Surveillance
DAPs	Downlink Aircraft Parameters
DF	Downlink Format
EASA	European Aviation Safety Agency
EHS	Mode S Enhanced Surveillance
ELM	Extended Length Message
ELS	Mode S Elementary Surveillance
ES	Extended Squitter
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTORL	European Organization for the Safety of Air Navigation
FCU	Flight Control Unit
FIR	Flight Information Region
FLTID	Flight Identification (transmitted by aircraft)
FMS	Flight Management System
FRUIT	False Relies Unsynchronized In Time
FS	Flight Statud
FTE	Flight Technical Error
HDG	Heading
HRD	Horizontal Reference Direction
GICB	Ground-Initiated Comm-B
GNSS	Global Navigation Staellite System
GVA	Geometric Vertical Accuracy
HMI	Human Machine Interface
IC	Interrogator Code
ICAO	International Civil Aviation Organization

ID	Identity
IFR	Instrument Flight Rules
II	Interrogator Identifier
IRF	Interrogation Repetition Frequency
MCP	Mode Control Panel
MET	Meteorological
MHz	Megahertz
MIP	Mode Interlace Patterns
MIT	Massachusetts Institute of Technology
MLAT	Multilateration
MOPS	Minimum Operational Performance Standard
MSAW	Minimum Safe Altitude Warning
MSP	Mode S Specific Protocol
MTCD	Medium Term Conflict Detection
NAC	Navigation Accuracy Category
NIC	Navigation Integrity Category
NUC	Navigation Uncertainty Category
RA	Resolution Advisory
RVSM	Reduced Vertical Separation Minimum
SARPs	(ICAO) Standards and Recommended Practices
SFL	Selected Flight Level
SI	Surveillance Identifier
SIL	Surveillance Integrity Level
SSR	Secondary Surveillance Radar
STCA	Short-Term Conflict Alert
TCAS	Traffic Alert and Collision Avoidance System
TRK	Track Angle
TVE	Total Vertical Error
UTC	Universal Time Coordinated
WAM	Wide Area Multilateration
WG	Working Group

3. REFERENCE DOCUMENTS

Id	Name of the document	Edition	Date	Origin	Domain
1	Aeronautical Telecommunications, Annex 10 - Vol. III - Communication Systems	Edition 2	2007	ICAO	
2	Aeronautical Telecommunications, Annex 10 - Vol. IV - Surveillance Radar and Collision Avoidance Systems	Edition 5	2014	ICAO	
3	Doc 9871, Technical Provisions for Mode S Services and Extended Squitter.	Edition 2	2012	ICAO	
4	Doc 9688 Manual on Mode S specific service.	Edition 2	2004	ICAO	
5	ED-73E, Minimum Operational Performance Standards for Secondary Surveillance Radar Mode S Transponders.	Edition 1	May 2011	EUROCAE	
6	ADS-B Implementation and Operations Guidance Document (AIGD)	Edition 13	April 2021	ICAO APAC	
7	Concept of Operations Mode S in Europe (Mode S CONOPS)	Edition 2	November 2013	Eurocontrol	
8	Mode S Elementary Surveillance (ELS) Operations Manual	Edition 1	January 2011	Eurocontrol	
9	Asia/Pacific Seamless ATM Plan		May 2015	ICAO APAC	
10	Doc 9924 Aeronautical Surveillance Manual	Third Edition	2020	ICAO	
11	Preliminary System Safety Analysis for the Mode S Elementary Surveillance	Edition 1.8	April 2004	Eurocontrol	EATMP
12	Elementary Surveillance (ELS) and Enhanced Surveillance (EHS) validation via Mode S Secondary Radar		April 2008	MIT Lincoln Laboratory	ATC Project
13	Aircraft Derived Data Validation Algorithms		August 2012	MIT Lincoln Laboratory	ATC Project
14	Doc.4444 Procedures For Air Navigation Services Air Traffic Management	Sixteenth Edition	November 2016	ICAO	
15	Clarification Mode S Transponder in an Airport/A-SMGCS Environment	Edition 1.1	3 May 2005	Eurocontrol	

16	Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System /Mode Select (ATCRBS / Mode S) Airborne Equipment	Edition E	17 March 2011	RTCA	
17	MARK 4 AIR TRAFFIC CONTROL TRANSPONDER (ATCRBS/MODE S)	Edition 4	15 November 2011	ARINC	
18	DO-260 Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B)		13 September 2000	RTCA	
19	DO-260A Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)		2003	RTCA	
20	DO-260B Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)		2 December 2009	RTCA	
21	Doc9574 Manual on a 300 m(1 000 ft) Vertical Separation Minimum Between FL 290 and FL410 Inclusive	Edition 3	2012	ICAO	

4. DESCRIPTION OF MODE S DAPs DATA

Inside the aircraft transponder, DAPs are stored in different BDS Registers for responding to interrogation requests by a Mode S ground system. Aircraft parameters are periodically delivered from aircraft sensors, flight management system, etc., to these registers via the downlink standard length transaction interface. BDS Registers, which have not been updated within the specified maximum update interval, are cleared or indicated as invalid and such aircraft parameters would be unavailable for ground interrogations. When a Mode S SSR sends an interrogation requesting the downlink of registers, Mode S SSR DAPs are packed into Comm-B format (known as “MB” field) and are extracted using either the GICB protocol or Mode S specific protocols (MSPs) channel 3. Mode S transponder transmit extended squitter to broadcast ADS-B DAPs.

BDS Registers are identified by a two-digit hex number. For example, BDS Register for selected vertical intention, which is identified by hex number 40₁₆, is commonly written as BDS code 4, 0 in publications. Depending on the stage of Mode S implementation, i.e., Mode S ELS and Mode S EHS, the scope of Mode S SSR DAPs data involved would be different as illustrated in the following subsections. These subsections also describe ADS-B DAPs data and the differences between Mode S SSR DAPs and ADS-B DAPs.

Detailed data format and maximum update interval of each BDS register are given in “ICAO Doc 9871 - Technical Provisions for Mode S Services and Extended Squitter”.

4.1 Mode S Downlink Format

There are 25 downlink formats, of which a number are reserved. DF0/16 are used for air-air surveillance, while DF18 is used for Extended squitter non transponder. The list below is only for DF4/5/11/17/20/21.

00100	FS:3	DR:5	UM:6	AC:13	AP:24
00101	FS:3	DR:5	UM:6	ID:13	AP:24
01011	CA:3	AA:24			PI:24
10001	CA:3	AA:24			ME:56 PI:24
10100	FS:3	DR:5	UM:6	AC:13	MB:56 AP:24
10101	FS:3	DR:5	UM:6	ID:13	MB:56 AP:24

FS: Flight status, contains information about alert(s), SPI and whether the aircraft is airborne or on the ground.

DR: Downlink request, contains a request to downlink information.

UM: Utility message, contains transponder communications status information.

AC: Altitude code, contains the altitude coded as special method.

AP: Address/parity, contains parity overlaid on the aircraft address.

ID: Identity, contains the aircraft identity code in accordance with the pattern for Mode A replies.

CA: Capability, contains information on the transponder level and some additional information.

AA: Aircraft Address.

PI: Parity/interrogator identifier, the parity overlaid on the interrogator’s identity.

ME: Message, extended squitter.

MB: Message, Comm-B,

#Note: For more detailed information, please refer to Aeronautical Telecommunications, Annex 10 - Vol. IV - Surveillance Radar and Collision Avoidance Systems.

4.2 Mode S ELS

In Mode S ELS implementation, aircraft and ground Mode S system should be compliant with providing the following functionalities over conventional Mode A/C systems:

- a) Selective interrogation.
- b) Use of ICAO Aircraft Address.
- c) Automatic reporting of ACID.
- d) Report of transponder capability;.
- e) Altitude reporting with a resolution of 25ft (subject to aircraft capability).
- f) Provision of flight status to indicate airborne or on-the-ground (subject to aircraft capability).
- g) Report of SI Code capability; and
- h) ACAS active resolution advisory report (when equipped with TCAS).

DAPs associated with Mode S ELS are stored in BDS code 1,0, BDS code 1,7, BDS code 2,0 and BDS code 3,0 registers of the aircraft's transponder.

Table 4-1 DAPs in Mode S ELS

Register	Name	Usage
BDS code 1,0	Datalink Capability Report	To report the data link capability of the Mode S transponder/data link installation.
BDS code 1,7	Common Usage GICB Capability Report	To indicate common usage GICB services currently supported.
BDS code 2,0	Aircraft Identification	To report aircraft identification to the ground.
BDS code 3,0	ACAS Resolution Advisory Report	To report ACAS active resolution advisory

With the above functionalities properly configured, Mode S ELS could bring the following benefits to ATC operations:

- a) Provide unambiguous aircraft identification using the unique aircraft address and aircraft identification.
- b) Help to solve Mode 3/A code shortage in congested airspace, using the Mode S conspicuity code (A1000) instead of discrete Mode 3/A codes.
- c) Improve surveillance data integrity by;
 - 1) reducing synchronous garble*,
 - 2) lessening over-interrogations, and
 - 3) simplifying aircraft identification in case of false targets.

- d) Improve the accuracy of multi-surveillance tracking and safety nets with more accurate target detection from Mode S radars and high resolution in altitude reporting; and
- e) Able to process more aircraft tracks than conventional Mode A/C radars; and
- f) Able to provide ACAS active resolution advisory from suitably equipped aircraft.

*Note, while Mode S will help to reduce data garble it will not resolve the issue. Issues around multi-path and different transponder types in close proximity (e.g., Mode A/C near a Mode S transponder) can mean that the return received by the radar may not be correct. In the case of a Mode A/C transponder close to a Mode S transponder, instances have been recorded where the Mode S address has been transposed into the reply from the Mode A transponder.

4.3 Mode S EHS

Mode S EHS implementation includes all the features of Mode S ELS with the addition of DAPs stored in BDS code 4,0, BDS code 5,0 and BDS code 6,0 registers of the aircraft's transponder. The following table summarizes the details of DAPs of these three registers:

Table 4-2 DAPs in Mode S EHS

Register	Name/Downlink Aircraft Parameters		Usage
BDS code 4,0	Selected Vertical Intention	MCP/FCU Selected Altitude	To provide information about the aircraft's current vertical intentions
		FMS Selected Altitude	
		Barometric Pressure Setting	
		MCP/FCU Mode	
		Target Altitude Source	
BDS code 5,0	Track and Turn Report	Roll Angle	To provide track and turn data to the ground systems.
		True Track Angle	
		Ground Speed	
		Track Angle Rate	
		True Air Speed	
BDS code 6,0	Heading and Speed Report	Magnetic Heading	To provide heading and speed data to ground systems.
		Indicated Air Speed	
		Mach Number	
		Barometric Altitude Rate	
		Inertial Vertical Velocity	

In addition to those improvements contributed by Mode S ELS in Section 4.1, Mode S EHS implementation provides the following benefits to ATC operation:

- a) Further improve multi-surveillance tracking accuracy and performance through the use of DAPs on track, turn, speed and heading of the aircraft in the track calculation.
- b) Further improve the accuracy of safety nets, e.g., Short-Term Conflict Alert (STCA), through the provision of more accurate aircraft tracks, and Medium-Term Conflict Detection (MTCD), Minimum Safe Altitude Warning (MSAW), through the provision of the earlier judgment of vertical movement.
- c) Allow the implementation of new safety nets in ATM automation system for cross-checking selected aircraft vertical intention (i.e., Selected Altitude) with ATC controllers' instruction as well as verifying the barometric pressure setting applied in the aircraft with QNH setting in ATM automation system; and

- d) Improve situational awareness of ATC controllers by enabling the direct access of aircraft parameters in ATM automation system, e.g., Indicated Air Speed, Mach speed, Selected Altitude, Barometric Pressure Setting, etc.
- e) Progressive reduction of R/T workload per aircraft.

4.4 ADS-B DAPs

According to the current situation and operation requirements of airborne ADS-B transponder, only the aircraft downlink parameters corresponding to ADS-B 1090ES Version 2 are considered. DAPs associated with ADS-B are stored in BDS Code 0,5, BDS Code 0,6, BDS Code 0,8, BDS Code 0,9, BDS Code 6,1, BDS Code 6,2 and BDS Code 6,5.

The following table summarizes the details of these parameters:

Table 4-3 ADS-B DAPs

Register	Name/Downlink Aircraft Parameters		Usage
BDS code 0,5	Airborne Position	Airborne Position	To provide accurate airborne position information
		NIC Supplement-B	
		Pressure Altitude	
		GNSS Height	
BDS code 0,6	Surface Position	Surveillance Status	To provide accurate surface position information.
		Surface Position	
		Ground Speed Vector	
BDS code 0,8	Aircraft Identification and Category	Aircraft Identification	To provide aircraft identification and category
		Emitter Category	
BDS code 0,9 Subtype 1/2	Velocity Over Ground	Ground Speed Vector	To provide additional state information for both normal and supersonic flight
		NACv	
		Vertical Rate	
		Intent Change Flag	
		Difference from Baro Altitude	
BDS code 0,9 Subtype 3/4	Airspeed and Heading	Air Speed	To provide additional state information for both normal and supersonic flight based on airspeed and heading
		Heading	
		NACv	
		Vertical Rate	
		Intent Change Flag	
		Difference from Baro Altitude	
BDS code 6,1 Subtype 1	Emergency/Priority Status	Emergency/Priority Status	To provide additional information on aircraft status
		Mode A Code	
BDS code 6,1 Subtype 2	ACAS RA Broadcast	ACAS RA Report	To report RAs generated by TCAS/ACAS equipment.
BDS code 6,2 Subtype 1	Target State and Status Message	Selected Altitude	To provide aircraft state and status information
		Barometric Pressure Setting	
		Selected Heading	
		NAC _P , SIL, NIC _{BARO} ,	
		SIL Supplement	
		MCP/FCU Mode	
		TCAS/ACAS Operational	
BDS code 6,5		Airborne Capability Class	

Subtype 0	Aircraft Operational Status- While Airborne	Airborne Operational Mode	To provide the capability class and current operational mode of ATC-related applications and other operational information.
		MOPS Version	
		NIC Supplement-A	
		NAC _P , GVA, SIL, NIC _{BARO}	
		HRD	
		SIL Supplement	
BDS code 6,5 Subtype 1	Aircraft Operational Status-On the Surface	Surface Capability Class	
		Length/Width	
		Surface Operational Mode	
		MOPS Version	
		NIC Supplement-A	
		NAC _P , SIL	
		TRK/HDG	
		HRD	
		SIL Supplement	

4.5 The Data Item in SSR DAPs and ADS-B DAPs

The airborne Mode S transponder may transmit the same data item to radar and ADS-B via different routes. The following table summarizes some of the parameters in use.

Table 4-4 The Data Item in SSR DAPs and ADS-B DAPs

Data Items	SSR DAPs		ADS-B DAPs	
	BDS/DF	ASTERIX	BDS/DF	ASTERIX
Aircraft Address	DF4/5/20/21 AP DF11 AA	I048/220	DF17 AA	I021/080
Mode A Code	DF5/21_ID	I048/070	BDS Code 6,1	I021/070
Pressure Altitude	DF4/20_AC	I048/090	BDS Code 0,5	I021/145
Airborne/On-the-ground	DF4/5/20/21_FS	I048/230	Determine by position message type (BDS Code 0,5 or 0,6)	I021/040
Aircraft Identification	BDS Code 2,0	I048/240	BDS Code 0,8	I021/170
Aircraft Emitter Category	-	-	BDS Code 0,8	I021/020
Special Position Indication/SPI	DF4/5/20/21_FS	I048/020 I048/230	BDS Code 0,5	I021/200
Emergency Status	DF5/21_ID	I048/230 I048/070	BDS Code 6,1	I021/200
ACAS RA Report	BDS Code 3,0	I048/260	BDS Code 6,1	I021/260
MCP/FCU Selected Altitude	BDS Code 4,0	I048/250	BDS Code 6,2	I021/146 I021/148
FMS Selected Altitude	BDS Code 4,0		BDS Code 6,2	I021/146
Barometric Pressure Setting	BDS Code 4,0		BDS Code 6,2	I021/REF
MCP/FCU Mode	BDS Code 4,0		BDS Code 6,2	I021/148 I021/REF
Roll Angle	BDS Code 5,0		-	I021/230
True Track Angle	BDS Code 5,0		BDS Code 0,9+6,5 BDS Code 0,6+6,5	I021/160
Ground Speed	BDS Code 5,0		BDS Code 0,9 BDS Code 0,6	I021/160

Track Angle Rate	BDS Code 5,0		-	I021/165
True Air Speed	BDS Code 6,0		BDS Code 0,9	I021/151
Magnetic Heading	BDS Code 6,0		BDS Code 0,9+6,5 BDS Code 0,6+6,5	I021/152
Indicated Air Speed	BDS Code 6,0		BDS Code 0,9	I021/150
Mach Number	BDS Code 6,0		-	-
Barometric Altitude Rate	BDS Code 6,0		BDS Code 0,9	I021/155
Inertial Vertical Velocity	BDS Code 6,0			-
Position in WGS-84 Co-ordinates	-	-	BDS Code 0,5 BDS Code 0,6	I021/130 I021/131
GNSS Height	-	-	BDS Code 0,5 + 0,9 BDS Code 0,5	I021/140
Geometric Vertical Rate	-	-	BDS Code 0,9	I021/157
Quality Indicator	-	-	BDS Code 0,5 BDS Code 0,9 BDS Code 6,2 BDS Code 6,5	I021/090
Aircraft Length and Width	-	-	BDS Code 6,5	I021/271
GNSS Antenna Offset	-	-	BDS Code 6,5	I021/REF

Note: The airspeed and magnetic heading values are only available from airborne participants that are not providing information about their velocities over the ground in ADS-B DAPs.

4.6 DAPs Data Exchange Protocol Between Surveillance and ATM Automation System

The decoding of DAPs data from downlink messages is handled by ground surveillance equipment such as radars, ADS-B, MLAT and WAM ground stations. The Surveillance Data Processor (SDP) within the ATM automation system can combine multiple downlink messages into a single target report for display to controllers. All Purpose Structured EUROCONTROL Surveillance Information Exchange (ASTERIX) formats are commonly used as the protocol for target report transmission from surveillance systems to the ATM automation system.

For detailed information about ASTERIX formats please refer to the following link of EUROCONTROL web site:

<https://www.eurocontrol.int/asterix>

ASTERIX formats are categorized based on the types of surveillance data involved. ASTERIX Category 20, ASTERIX Category 21 and ASTERIX Category 48 are responsible for the DAPs data transmission from MLAT systems, ADS-B systems and radars respectively. For each ASTERIX category, the protocol format is further divided into different editions with variations on the supported DAPs data. ANSP's should carry out appropriate studies on the available protocol editions during the design stage to ensure the chosen format can cater to the scope of DAPs proposed to be implemented and that the Surveillance and ATM automation systems can correctly process the protocol selected.

For details, previous and current versions of ASTERIX Category 20, Category 21 and Category 48 specification documents can be downloaded from the following link of EUROCONTROL web sites:

<https://www.eurocontrol.int/publication/cat020-eurocontrol-specification-surveillance-data-exchange-asterix-part-14-category-20>

<https://www.eurocontrol.int/publication/cat021-eurocontrol-specification-surveillance-data-exchange-asterix-part-12-category-21>

<https://www.eurocontrol.int/publication/cat021-eurocontrol-specification-surveillance-data-exchange-asterix-part-12-category-0>

<https://www.eurocontrol.int/publication/cat048-eurocontrol-specification-surveillance-data-exchange-asterix-part4>

5. IMPLEMENTATION PRINCIPLES AND PHASES

Implementation guidance is developed to progress the DAPs implementation from concept to operational use in the ICAO APAC region. In this chapter, section one addresses the implementation principles, which describes the issues of international coordination, system compatibility, data integrity and system integration, while section two addresses the implementation phase, to assist States with the management of DAPs implementation activities.

5.1 Implementation Principles

5.1.1 Stakeholders Coordination

DAPs provide useful information from aircraft which can benefit ANSP and airspace users. Improvements in efficiency and safety can be achieved, however the resultant changes in operational procedures to provide the improvements, will affect ANSPs, Regulators, Airlines, and other related airspace users. Before implementation by any State, a coordination team should be formed to study, coordinate, support and consult the implementation plans and related activities. The coordination team should include field experts on avionics, data link, surveillance infrastructures and end users.

Changes in the ATM operational procedures as the result of the use of DAPs require coordination among ATS providers, Regulators, Airlines, and where applicable, coordination among neighboring States to maximize the benefits. All States are encouraged to share their operational experiences, and to report anomalies through Mode S DAPs WG and the Surveillance Implementation Coordination Group.

Not all Surveillance and ATM automation systems are capable of processing and using DAPs, therefore investment in all related fields needs to be considered by all States. The coordination team should be consulted for future investment plans and related activities considering the technical and operational aspects. Consideration needs to be given to achieve a balance between investment and benefits.

5.1.2 System Compatibility

a) Technical:

DAPs can be obtained by different surveillance technologies such as Mode S Radar, ADS-B, MLAT and WAM, however not all the transponders can support DAPs. Different surveillance technologies in the ICAO APAC States mean that system compatibility should be considered.

Potential interference between different surveillance technologies should be fully considered before implementation, otherwise the efficiency and safety of the system cannot be ensured. Harmonization between different technologies should be considered and optimized to reduce the RF congestion on 1030MHz and 1090MHz.

Since not all aircraft are equipped with Mode S transponders, and not all the Mode S transponders have the ability to support DAPs, compatibility and efficiency should always be considered before implementation.

When DAPs are implemented, the data rate will increase compared to the conventional radar data, and the related BDS information extraction strategies should be considered. To reduce the load on the 1090MHz spectrum, only those registers intended for operational use should be interrogated/extracted.

b) Operational:

Different processing systems can support DAPs in different levels, hence the quality and information of the target may be different after the processed DAPs have been added. For example, some radar tracking

algorithms will consider DAPs as an input to the tracking, so the quality and information of the target will be a little bit different, therefore there should be compatibility considerations between different systems before use of the target data.

There are different air traffic management and operation strategies used by neighboring States. So, the operational procedures should always consider the operational compatibilities. For example, Mode A/C transponders and Mode S transponders may be working in the same area.

5.1.3 DAPs Data Integrity

DAPs data integrity should always be the first consideration when putting DAPs data into use. Since the data integrity from the source is not delivered by any related BDS register now, States are encouraged to find a reliable methodology to ensure the data integrity before the use of the data. Additionally, ongoing means of determining data integrity should be implemented, along with an ability to exclude invalid DAPs data from ATM automation systems.

States which already have experience on data integrity are encouraged to share this information with other States. The coordination team could support and harmonize this activity, and provide a standard method to evaluate the data integrity, and share the method with all the States.

5.1.4 System Integration

By introducing DAPs, the target characteristic from the source to the end user may be different compared to pre-DAPs implementation. In different phases of the processing flow of target data, DAPs can be used by different systems to improve tracking performance. Some key points in the data flow are as follows:

a) Airborne Avionics Systems

As DAPs data comes from different kinds of sensors and avionics systems on the aircraft, the reliability of the data should be ensured before the data is used operationally. Research has shown that some BDS data is missing or not updated correctly. The reasons for this need to be established, as it can mean that the use of some DAPs data is not suitable for implementation. Examples of issues include:

- 1) Older Flight Management Systems which do not provide all the DAPs data, and
- 2) Incorrect installation (e.g., onboard equipment wired to wrong registers)

b) Ground Sensor Systems

Ground sensors may use the DAPs to improve their target tracking performance, having an impact on the tracking function; the target data produced by this kind of sensors will show different characteristics to the pre-DAPs implemented tracking function, such as the turning rate, the kinematic movement and so on. Data users need to be aware of this performance improvement.

c) Ground Automation Systems

Ground automation systems can use DAPs information for a wide variety of uses, such as for tracking, safety net processing, situational awareness, en-route meteorological information sharing and so on. Ensuring DAPs information is processed and used in an appropriate way should be considered during implementation.

d) Other Surveillance Systems

Any DAPs data should be capable of being integrated with other surveillance systems data, and any potential difference and impact should be considered before use. Some of the information can be cross checked by different surveillance technologies.

- e) Other Related Systems

5.2 Implementation CHECKLIST

The purpose of this implementation checklist is to document the range of activities that need to be considered to bring a DAPs application from an initial concept to operational use. Some activities of this checklist may be specific to individual stakeholders.

5.2.1 Activity Sequence

The activities are listed in approximate sequential order. However, each activity does not have to be completed prior to starting the next activity. In many cases, a parallel and iterative process should be used to feed data and experience from one activity to another. It should be noted that not all activities will be required for all applications.

5.2.2 Concept Phase

- a) Construct operational concept:
 - 1) Purpose.
 - 2) Operational environment.
 - 3) ATM functions; and
 - 4) Infrastructure.
- b) Identify benefits:
 - 1) Safety enhancements.
 - 2) Efficiency.
 - 3) Capacity.
 - 4) Environmental.
 - 5) Cost reductions.
 - 6) Accessibility; and
 - 7) Other metrics (e.g., predictability, flexibility, usefulness);
- c) Identify constraints:
 - 1) Air-Ground interoperability.
 - 2) Compatibility with non-equipped aircraft.
 - 3) Need for exclusive airspace.
 - 4) Required ground infrastructure.
 - 5) RF spectrum.
 - 6) Integration with existing technology.
 - 7) Technology availability; and
 - 8) Actuality of existing infrastructure.
- d) Prepare business case:
 - 1) Cost benefit analysis; and

- 2) Demand and justification.

5.2.3 Design Phase

- a) Identify operational requirements:
 - 1) Security; and
 - 2) Systems interoperability.
- b) Identify human factors issues:
 - 1) Human-machine interfaces.
 - 2) Training development and validation.
 - 3) Workload demands.
 - 4) Role of automation vs. role of human.
 - 5) Crew coordination/pilot decision-making interactions; and
 - 6) ATM collaborative decision-making.
- c) Identify technical requirements:
 - 1) Standards development.
 - 2) Prevailing avionics standards.
 - 3) Data required.
 - 4) Functional processing.
 - 5) Functional performance.
 - 6) Required certification levels; and
 - 7) Identify the infrastructure that needs upgrade.
- d) Equipment development, test, and evaluation:
 - 1) Prototype systems built to existing or draft standards/specifications.
 - 2) Upgrade and test scheme for the existing infrastructure.
 - 3) Developmental bench and flight tests.
 - 4) Acceptance test parameters: Acceptance test should be performed to ensure all the key indicators are met; and
 - 5) Select and procure technology.
- e) Develop procedures:
 - 1) Pilot and controller actions and responsibilities.
 - 2) Standardize the interaction and phraseologies.
 - 3) Controller's responsibility to maintain a monitoring function, if appropriate.
 - 4) System certification procedure should be made.
 - 5) Standard Operating Procedure should be made if the human machine interface of the system is changed.
 - 6) Contingency procedures: For example, duplicate Mode S address is detected.
 - 7) Emergency procedures, for example ACAS message is received.

- 8) General procedures for unforeseen issues should be made; and
 - 9) Develop AIP and Information documentation.
- f) Prepare design phase safety case:
- 1) Safety rationale.
 - 2) Safety budget and allocation; and
 - 3) Functional hazard assessment.

5.2.4 Implementation Phase

- a) Prepare implementation phase safety case.
- b) Conduct operational test and evaluation:
- 1) Flight deck and ATC validation simulations; and
 - 2) Flight tests and operational trials.
- c) Obtain systems certification:
- 1) Aircraft equipment; and
 - 2) Ground systems.
- d) Obtain regulatory approvals:
- 1) Air traffic certification of use.

e) Impact Assessment

An impact assessment should be conducted to gauge the effect in terms of security, efficiency, operating regulations, human factors, infrastructure, environment, and so on.

f) Implementation transition:

- 1) Promulgate procedures.

The regulatory authority shall promulgate general regulations to the participants. Each participant shall formulate corresponding detailed regulations.

- 2) Deliver training.

Training should be conducted to ensure the personnel is familiar with the standard, regulation, and technology of the Mode S DAPs implementation and operation. Licensing process could be executed if needed.

- 3) Continue data collection and analysis.
- 4) Resolve any unforeseen issues; and
- 5) Continue feedback into standards development processes.

g) Performance monitoring to ensure that the agreed performance is maintained.

6. SYSTEM INTEGRITY AND MONITORING

6.1 Introduction

CNS and ATM environment is an integrated system including physical systems (hardware, software, and communication networks), human elements (pilots, controllers, and engineers), and the operational procedures for its applications. The integration of Mode S DAPs with other surveillance technologies enables more information from an aircraft to be used to provide a safer service.

Because of the integrated nature of such system and the degree of interaction among its components, comprehensive system monitoring is recommended. The procedures described in this section aim to ensure system integrity by validation, identification, reporting and tracking of possible problems revealed during system monitoring with appropriate follow-up actions.

6.2 Personnel Licensing and Training

Prior to operating any element of the Mode S DAPs system, operational and technical personnel shall undertake appropriate training as determined by the ANSP or State Regulatory Authority, including compliance with the Convention on International Civil Aviation where applicable. Such training will ensure that personnel are familiar with the regulation, standards and requirements of the Mode S DAPs implementation and operation.

6.3 ATS System Validation

6.3.1 Safety Assessment Guidelines

To meet system integrity requirements, ANSPs or States should conduct a validation process that confirms the integrity of their equipment and procedures. Such processes shall include:

- a) A system safety assessment for new implementations is the basis for definitions of system performance requirements. Where existing systems are being modified to utilize additional services, the assessment demonstrates that the ATS Provider's system will meet safety objectives.
- b) Integration test results confirming interoperability for operational use of airborne and ground systems; and
- c) Confirmation that the ATS operation procedure is compatible with those of adjacent providers where the system is used across a common boundary.

6.3.2 System Safety Assessment

The objective of the system safety assessment is to ensure that the implementation and operation of Mode S DAPs are safe. The safety assessment should be conducted for implementation as well as any future enhancements and should include:

- a) Identifying failure or error conditions.
- b) Assigning levels of criticality.
- c) Determining risks/probabilities for occurrence.
- d) Identifying mitigating measures.
- e) Categorizing the degree of acceptability of risks; and

f) Operational hazard ID process.

Following the safety assessment, States should institute measures to offset any identified failure or error conditions that are not already categorized as acceptable. This should be done to reduce the probability of their occurrence to an acceptable level. This could be accomplished through the automation of procedures.

6.3.3 Integration Test

States should conduct trials with suitably equipped aircraft to ensure the DAPs data meets the operational and technical requirements to provide ATS. The introduction of the Mode S DAPs will give more information about the aircraft, and should not affect the performance of the existing system. States should be satisfied by test results and analysis carried out by the ANSP.

6.3.4 ATS Operation Manuals

States may coordinate with adjacent States to confirm that their ATS operation manuals contain standard operating procedures to ensure harmonization of procedures that impact across common boundaries.

6.4 System Monitoring

During the implementation and operation of the Mode S DAPs technology, routine collection of data is necessary to ensure that the system continues to meet or exceed its performance, safety and interoperability requirements, and that operational service delivery and procedures are working as intended.

6.4.1 Consideration for System Monitoring

Mode S transponders may have been installed a long time ago to support mandatory ACAS functionality. The Mode A/C function has been permanently used by ATC, but the Mode S functions may not have been used. Any failure impacting Mode A/C would have been detected by ATC during normal operation and corrective action would have been undertaken. Before implementing Mode S for surveillance, system checks are usually made to ensure the correct operation of the Mode S transponders (e.g., continue to correctly process Mode A/C and Mode S replies), but possibly no system checks were made to ensure that the DAPs data was correct, so several undetected failures may have existed over the years of operation.

A number of Mode S transponder from different OEMs have been observed to be non-compliant with Annex 10 Volume IV requirements (e.g., no SI code capability, no reply to aircraft register extraction, incorrectly configured aircraft address, incorrect content of BDS registers), even though the transponder is certified to level 2. Although actions have been taken in some areas (mainly where Mode S has been implemented) to address these problems, some aircraft with Mode S which are not working correctly still operate (mostly in areas where Mode S has not yet been implemented).

During the initial deployment of European Mode S, it was discovered that avionics upgrade performed on some aircraft had resulted in erroneous transponder operations so that, in some cases, the aircraft could not even be detected by the ground radar. It is therefore recommended that before commencing Mode S surveillance operations in a given airspace, system monitoring be put in place for timely detection and rectification of hidden transponder problems. This will enable the ANSP and aircraft operators to remedy identified issues prior to using Mode S operationally.

The communication lines for transferring surveillance information in a Mode S radar require much higher data throughput as there is more information per aircraft. For example, compared to a Mode A/C radar, Mode S DAPs require up to three times more data throughput.

Mode S DAPs bring safety benefits even when only a portion of the traffic is properly equipped. Some aircraft can be configured to provide additional data items, but their use should be considered with caution since some airborne installations may not have been certified, hence data may be erroneous. System monitoring to validate the transmitted information is considered desirable for DAPs operation.

6.4.2 Mode S DAPs Problem Reports

During the application of the Mode S DAPs, some problems may be found during the observation of one or more specific events. Faulty Mode S DAPs data should be recorded and analyzed. Problems may be found during the routine analysis of application data. Any problem should be documented and reported to the DAPs WG.

After a problem has been found, the finder can attempt to resolve it with the appropriate party and report the solution to the DAPs WG. The problem and solution will be distributed to the DAPs WG members. If the problem has not been resolved, the problem should be reported to the DAPs WG, and members will be encouraged to resolve the problem. In many cases, a Mode S DAPs problem will be systematic across a particular aircraft or avionics configuration. Engagement with, and correction by the manufacturer may be required.

The mode S DAPs problem should be reported with the form as shown in Table 6-1.

Table 6-1 Mode S DAPs Problem Report Form

PRS#			
Start Time/Date UTC		End Time/Date UTC	
Registration		Aircraft ID	
Flight ID		ICAO Aircraft Address	
Aircraft Type			
Flight Sector/ Location			
ATS Unit			
Description / additional information			
Originator		Originator Reference number	
Organization			

PRS#:	A unique identification number assigned by the PRS Administrator to this problem report. Organizations writing problem reports are encouraged to maintain their internal list of these problems for tracking purposes. Once the problems have been reported to the PRS and incorporated in the database, a number will be assigned by the PRS and used for tracking by the SURICG.
Start Time/Date UTC:	UTC time/date when the event started.
End Time/Date UTC:	UTC time/date when the event ended.
Registration:	Registration number (tail number) of the aircraft involved.
Aircraft ID:	Coded equivalent of call sign as entered in FPL Item 7.
Flight ID:	The Flight ID/Flight Number downlinked from the aircraft.
ICAO Aircraft Address:	Unique aircraft address expressed in Hexadecimal form.
Aircraft Type:	The aircraft model involved. For the aircraft type designators please refer to ICAO Doc 8643.

Flight Sector/Location:	The departure airport and destination airport for the sector being flown by the aircraft involved in the event. For the airport indicators please refer to ICAO Doc 7910 or related AIP. Or if more descriptive, give the location of the aircraft during the event.
ATS Unit:	ICAO identifier of the ATC center or tower controlling the aircraft at the time of the event.
Originator:	Point of contact at the originating organization for this report (usually the author).
Organization:	The name of the organization (airline, ATS provider or communications service provider) that created the report.
Description:	This should provide as complete a description of the situation leading up to the problem as is possible. Where the organization reporting the problem is not able to provide all the information (e.g., the controller may not know everything that happens on the aircraft), it would be helpful if they would coordinate with the other parties to obtain the necessary information. The description should include: a) A complete description of the problem that is being reported b) The route contained in the FMS and flight plan c) Any flight deck indications d) Any indications provided to the controller when the problem occurred e) Any additional information that the originator of the problem report considers might be helpful but is not included on the list above If necessary, to contain all the information, additional pages may be added. If the originator considers it might be helpful, diagrams and other additional information (such as printouts of message logs) may be appended to the report.

6.4.3 Example of Mode S DAPs Problem

Through monitoring, it has been reported that erroneous DAPs data have been observed due to failure or improper setting/installation of Mode S equipment. A Working Paper of the ICAO Surveillance Panel Working Group (WP ASP12-20) has indicated that a lot of incorrect, outdated and even erroneous data and parameters are present for DAPs data. The errors and/or miss-matches can be frequent, including:

- a) The ACID is not always correct (erroneous)
- b) The Selected Altitude is not correct or is not updated (For example Selected Altitude data should be provided by the MCP/FCU instead of the FMS as the FMS data is usually incorrect).
- c) Mode S DAPs data does not correspond to the content of the requested register (BDS swap).

6.5 Application Analysis

During the Operation of Mode S DAPs application, the analysis is necessary to ensure that the system continues to meet or exceed its performance, safety, and interoperability requirements. To analyze the Mode S DAPs applications, routine data should be recorded.

6.5.1 Data Recording

It is recommended that ATS providers and communication service providers retain the records defined below for at least 30 days to allow for accident/incident investigation processes. These records should be made available on request to the relevant State safety authority. Where data is sought from an adjacent State, the usual State to State channels should be used.

Where possible these recordings shall be in a form that permits a replay of the situation and identification of the messages that were received by the ATS system. Data exchange across borders may not be possible due to different Radar or ATM message formats or to State regulatory issues.

Not only the data from ground equipment, but also the data from aircraft equipment should be recorded. By analyzing the recorded data, the exact reason for the failures can be found.

6.5.2 Local Data Collection

ATS providers and communication service providers should identify and record Mode S DAPs system component failures that have the potential to negatively impact the safety of controlled flights or compromise service continuity.

6.5.3 Avionics Problem Identification and Correction

ATS providers should develop systems or procedures to:

- a) detect Mode S DAPs avionics anomalies and faults
- b) advise the regulators and where appropriate the aircraft operators on the detected Mode S DAPs avionics anomalies and faults
- c) devise mechanisms and procedures to address identified faults

Regulators should ensure that appropriate corrective actions are taken to address identified faults.

An example of Mode S DAPs analysis is taken in Appendix 1.

6.6 Identified Issues

Several identified issues had already been recognized during the implementation of the Mode S DAPs data application in the ATM automation system. Some of them even disrupted the operation of ATC services. Thus, it is necessary to ensure the reliability of DAPs for utilization for ATC operation. This section will present some issues for helping to figure them out.

Based on the experience gained from States, the common Mode S SSR DAPs problems are summarized under different categories in Appendix 2, and ADS-B DAPs problems can refer to the Appendix 2 of AIGD. It is noted that many cases of the wrong DAPs found in Mode S implementation were because of the aircraft avionics capability. Some issues resulted from human factors. Experiences showed that it was important to keep close coordination with airlines to promote the DAPs application. Airlines should be informed of the issues in time and to check their aircraft Mode S transponders promptly. At the same time, airlines need to improve their working procedures including ensuring they file flight plans correctly.

7. REGULATIONS AND PROCEDURES

Mode S DAPs involve the transmission of specific data from aircraft. These data messages can be interrogated by the ground equipment (Mode S interrogator) or broadcast by the Mode S extend squitter. ATM uses the data to show the more precise and integrated situation of the surveilled aircraft. The following procedures relate to the use of Mode S DAPs data in ATS ground surveillance applications.

The implementation of the Mode S DAPs system will support the provision of high-performance surveillance, enhancing flight safety, improving the controller efficiency, and reducing the workload of both the controller and pilot.

7.1 Mandating Mode S DAPs

- a) Depending on the type of operations that States are going to conduct, States will have to consider whether there is a need to publish mandates. Some operations will require all aircraft within airspace to be suitably equipped while others can still work well on a ‘best equipped best served’ basis.
- b) Use of Multilateration on airport surface is an example of an operation where it is recommended for all aircraft to be equipped with Mode S transponders. Another example is the conspicuity code environment, where Flight Identification may be used as the prime means to couple/correlate flight plans, allowing ANSPs to overcome the shortage of Mode A codes. Equipage mandates would be necessary for such operations.
- c) States intending to implement ADS-B based surveillance services may designate portions of airspace within their area of responsibility by:
 - i. *mandating the carriage and use of ADS-B equipment; or*
 - ii. *providing priority for access to such airspace for aircraft with operative ADS-B equipment over those aircraft not operating ADS-B equipment.*
- d) With appropriate software, ATM automation systems can use Mode S DAPs to provide additional information to controllers, enabling a reduction in controller workload and the enhancement of Safety Net systems. Equipage mandates are not necessary, but consideration of the nature of the services required and/or a cost-benefit study, may warrant such mandates.
- e) As of May 2018, examples of States which use Mode S SSR DAPs without publishing mandates are Australia¹, New Zealand and Singapore. Examples of States with published mandates for Mode S SSR DAPs are France, Germany and the United Kingdom.
- f) In publishing mandate/regulations, States should:
 - 1) Define the standards applicable to the State.
 - i. E.g., *Joint Aviation Authorities (JAA) Temporary Guidance Leaflets (TGL) 13 Revision 1* for Elementary Surveillance in version 0 and version 1 transponders; or
 - ii. E.g., *European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 20-13* for Enhanced Surveillance in version 0 and version 1 transponders; or

¹ Australia has a mandate for Mode S transponders at selected airports utilizing Multilateration for surface surveillance, but no widespread mandates for airborne DAPs usage

- iii. E.g., *Elementary Surveillance (ELS) requirements stated in European Aviation Safety Agency (EASA) CS-ACNS-Subpart D, Section 2 (i.e., CS ACNS.D.ELS) for Elementary Surveillance in version 2 transponder; or*
 - iv. E.g., *Enhanced Surveillance (EHS) requirements stated in European Aviation Safety Agency (EASA) CS-ACNS-Subpart D, Section 3 (i.e., CS ACNS.D.EHS) for Enhanced Surveillance in Version 2 transponder*
 - v. E.g., *Mode S level 2 if the requirement is simply for Airport Surface Multilateration.*
 - vi. *, ADS-B avionics compliant to Version 2 ES (equivalent to RTCA DO-260B) or later version 2.*
 - vii. E.g., *European Aviation Safety Agency - Certification Considerations for the Enhanced ATS in Non-Radar Areas using ADS-B Surveillance (ADS-B-NRA) Application via 1090 MHZ Extended Squitter (AMC 20-24);or*
 - viii. E.g., *European Aviation Safety Agency - Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance Subpart D — Surveillance (SUR) (CS-ACNS.D.ADS-B);or*
 - ix. E.g., *Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems; or*
 - x. E.g., *the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.*
- 2) Define the airspace affected by the regulations
 - i. E.g., *Within the [FIR Authority] Flight Information Region above Flight Level XXX*
 - 3) Define the category of aircraft that the regulation applies to
 - i. E.g., *Aircraft with a maximum certified take-off mass exceeding 5,700 kg or having a maximum cruising true airspeed capability greater than 250 kt; or*
 - ii. E.g., *All IFR aircraft*
 - 4) Define the timing of the regulations allowing sufficient time for operators to equip.
 - i. E.g., *With effect from 1 Jan 2020.*

Note: More information of mandate for 1090 MHz ADS-B can refer to section 9.2 of AIGD.

7.2 Avionics

7.2.1 Mode S Transponder Capabilities

- a) The various levels of capabilities for Mode S Transponders are described in subsequent paragraphs. The state should select the capability as required by its operations.
- b) According to ICAO Annex 10, Vol. 4, Mode S transponders shall conform to one of five levels of capability as follows:
 - 1) Level 1 is the basic transponder. Level 1 permits surveillance based on Mode A/C as well as on Mode S. With a Mode S aircraft address, it comprises the minimum features for compatible operation with Mode S interrogators. It has no datalink capability and will not be used by international air traffic.

- 2) Level 2 has the same capabilities as Level 1 and permits standard length datalink communication from ground to air and air to ground. It includes automatic aircraft identification reporting. This is the minimum level permitted for international flights. Data parity with overlay control (ICAO Annex 10, Vol. 4, 3.1.2.6.11.2.5) for equipment certified on or after 1 January 2020.
 - 3) Level 3 has the capabilities as level 2 and also those prescribed for ground-to-air ELM communications.
 - 4) Level 4 has the capabilities as level 3 and also those prescribed for air-to-ground ELM communications.
 - 5) Level 5 has the capabilities as level 4 and also those prescribed for enhanced Comm-B and ELM communications.
- c) Other than the various levels, transponders also can have the following features:
- 1) Extended squitter - transponders that shall have the capabilities of level 2, 3, 4, or 5 and those prescribed for extended squitter operation.
 - 2) SI Capability - Transponders with the ability to process SI codes shall have the capabilities of level 2, 3, 4, or 5 and those prescribed for SI code operation.
 - 3) Data flash Application – transponders that implement the data flash mode.
 - 4) Hijack Mode Capability – transponders that support the Hijack Mode and have the capabilities of level 2, 3, 4, or 5.
 - 5) ACAS Compatibility –transponders compatible with ACAS.
 - 6) Antenna Diversity – in aircraft with transponder using two antennas, receivers and transmitting channels.
 - 7) According to ED-73E, Elementary Surveillance – elementary surveillance transponders will require at least a level 2 transponder and have the following capabilities:
 - i. Flight status reporting
 - ii. Barometric pressure altitude reporting
 - iii. Transponder capability (CA)
 - iv. II and SI code capable
 - v. Declaration of capability (BDS code 1,0)
 - vi. Common usage GICB capability report (BDS code 1,7)
 - vii. Mode S specific services capability (BDS code 1,8 to BDS code 1,C)
 - viii. Flight identification (BDS code 2,0)
 - ix. ACAS Active Resolution Advisory (BDS code 3,0) if equipped with ACAS II
 - x. Aircraft register (BDS code 2,1) – optional
 - 8) According to ED-73E, Enhanced Surveillance – enhanced surveillance transponders have the capabilities of elementary surveillance transponders, plus the capability to provide the following DAPs:
 - i. Magnetic Heading (BDS code 6,0)
 - ii. Indicated Airspeed and/or Mach No. (BDS code 6,0)
 - iii. Vertical Rate (climb/descend) (BDS code 6,0)
 - iv. True Airspeed (provided if Track Angle Rate is not available) (BDS code 6,0)
 - v. MCP/FCU Selected Altitude (BDS code 4,0)
 - vi. Ground Speed (BDS code 5,0)
 - vii. Roll Angle (BDS code 5,0)

- viii. Track Angle Rate (if available) (BDS code 5,0)
- ix. True Track Angle (BDS code 5,0)
- x. Barometric Pressure Setting (BDS code 4,0)

Note: For more information of transponder capabilities for 1090 MHz ADS-B refer to section 9.2 and appendix 3 of the AIGD.

7.2.2 Mode S Transponder Mandate

During the 31st APANPIRG meeting, the following Conclusion regarding the fitment of Mode S equipage was adopted, States/Administrations may consider the following conclusion when considering the publishing of Mode S transponder mandate.

Conclusion APANPIRG/31/14 (CNS SG/24/13 (SURICG/5/3(DAPS WG3/1))) - Mode S Forward Fit Equipage in APAC Region		
What:	Regarding fitment of Mode S equipage, That, States/Administrations in APAC Region be strongly encouraged to mandate that registered aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, with a date of manufacture on or after 1 January 2022 be equipped with Mode S avionics compliant with Enhanced Surveillance (EHS).	Expected impact: ☐ Political / Global ☐ Inter-regional ☒ Economic ☐ Environmental ☒ Ops/Technical
Why:	Considering that a number of DAPs applications will require EHS and that it's easy for new aircraft to be equipped with EHS. Retrofitting existing airframes with EHS will need further deliberation under the challenging pandemic situation.	Follow-up: ☒ Required from States
When:	16-Dec-20	Status: Adopted by PIRG
Who:	☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☒ APANPIRG ☐ ICAO HQ ☒ Other: SURICG	

7.2.3 Transition Guidelines

- a) Equipage of aircraft will be achieved over a period of time. Not all aircraft will be equipped with the necessary capability. A transition plan is required to accommodate varying degrees of aircraft equipment compliance.
- b) As part of the formulation for a transition plan, States should assess the impact of having aircraft that are not suitably equipped within the affected airspace, to enable the implementation of suitable mitigating measures. States should also collect statistics on the readiness of the aircraft within the affected airspace.
- c) For different operations, the mitigation measures in the transition plan could be different. For example, if the operation is just to use the Mode S DAPs to provide useful information to the controllers, the impact of having unequipped aircraft is minor. Mitigating measures could be as simple as making the controllers aware that not all aircraft are able to provide the information. On the other hand, where mode S is mandated for airport surface Multilateration, mitigating measures for having unequipped aircraft may include having special procedures for non-equipped aircraft or the deployment of a surface movement radar.

7.2.4 Mode S Transponder Working on the Ground

Table 7-1 summarizes the requirements to inhibit or not inhibit replies from aircraft on the ground.

Table 7-1 The Requirements of Transponders on Ground

Type of interrogations	Transponder reply
Mode A/C	Should be inhibited
Mode A/C/S All Call	Shall always be inhibited
Mode S only All Call (UF =11)	Shall always be inhibited
Mode S (Roll call UF=0,4,5,16,20,21,24)	Shall not be inhibited
Acquisition Squitter (Short Squitter)	Shall be inhibited if surface type of extended squitter is transmitted
Extended Squitter (Long Squitter)	Shall not be inhibited

[Information obtained from Eurocontrol's Clarification Mode S Transponder in an Airport/A-SMGCS Environment Ed 1.1 dated 3 May 2005]

- a) Replies to Mode A/C/S all call and Mode S only all call interrogations shall always be inhibited when the aircraft declares the on the ground state. It shall not be possible to inhibit replies to discretely addressed Mode S interrogations regardless of whether the aircraft is airborne or on the ground.
- b) Mode A/C replies should be inhibited (i.e., Mode A/C transponder set to standby) when the aircraft is on the ground to prevent interference when in close proximity to an interrogator or other aircraft. Mode S discretely addressed interrogations do not give rise to such interference. An exception on the recommendation to inhibit Mode A/C replies will be at airports having Multilateration systems working with Mode A/C.
- c) Mode S transponders shall be set to the correct mode according to its flight status (i.e., airborne mode when it's in the air and ground mode when on the ground). When an aircraft is in ground mode, replies to all call are inhibited. It is recommended that aircraft provide means to determine the on-the-ground state automatically and provide that information to the transponder.

7.2.5 1090MHz Extended Squitter Transponder capability

- a) According to the ICAO 1090MH ADS-B Minimum Operational Performance Standard (MOPS), in a Mode S Transponder-Based Subsystem, the ADS-B Message generation function and the modulator and 1090 MHz transmitter are present in the Mode S transponder itself. The transmit antenna subfunction consists of the Mode S antenna(s) connected to that transponder.
- b) According to ICAO Annex 10, Volume 4. Extended squitter ADS-B transmission requirements. Mode S extended squitter transmitting equipment shall be classified according to the unit's range capability and the set of parameters that it is capable of transmitting consistent with the following definition of general equipment classes:
 - 1) Class A extended squitter airborne systems support an interactive capability incorporating both an extended squitter transmission capability (i.e., ADS-B OUT) with a complementary extended squitter reception capability (i.e., ADS-B IN) in support of onboard ADS-B applications.
 - 2) Class B extended squitter systems provide a transmission only (i.e., ADS-B OUT without an extended squitter reception capability) for use on aircraft, surface vehicles, or fixed obstructions; and

- 3) Class C extended squitter systems have only a reception capability and thus have no transmission requirements.
- c) According to the ICAO 1090MHz ADS-B Minimum Operational Performance Standards (MOPS), the 1090ES ADS-B transponder has 4 versions, which included:
- 1) RTCA DO-260/EUROCAE ED-102 (Version 0)

The International Civil Aviation Organization issued the 1090ES ADS-B initial standard "Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B)" (DO-260/ED-102) in September 2000, and was known as ADS-B version 0. This version defines the 1090 MHz ADS-B Transmitting Subsystem takes position, velocity, status, and intent inputs from other systems onboard the aircraft and transmits this information on the 1090 MHz frequency as Mode S Extended Squitter messages.

According to DO-260/ED-102, the 1090ES transponder should send State Vector (SV), Mode Status (MS) Reports, and support the following DAPs capabilities:

- i. airborne position (BDS 0,5).
- ii. surface position (BDS 0,6).
- iii. identification and type (BDS 0,8).
- iv. airborne velocity (BDS 0,9).
- v. emergency/priority status (BDS 6,1).
- vi. Current/Next Trajectory Change Point (TCP) (BDS 6,2).
- vii. Current/Next Trajectory Change Point (TCP+1) (BDS 6,3).
- viii. Aircraft Operational Coordination Message (BDS6,4).
- ix. Aircraft operational status (BDS 6,5).

2) RTCA DO-260A (Version 1)

The International Civil Aviation Organization issued "Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Services - Broadcast (TIS-B)" (RTCA DO-260A) in April 2003, and was known as ADS-B version 1. The formats and protocols for 1090 ES were revised in part to overcome the limitation of the reporting of surveillance quality using only navigation uncertainty category (NUC). In the revised formats and protocols, surveillance accuracy and integrity are reported separately as:

- i. navigation accuracy category (NAC),
- ii. navigation integrity category (NIC), and
- iii. surveillance integrity level (SIL).

Other features added in Version 1 messages include the reporting of additional status parameters and formats for traffic information service — broadcast and ADS-B rebroadcast (ADS-R). Version 1 formats are fully compatible with those of Version 0, in that a receiver of either version can correctly receive and process messages of either version.

According to D0-260A, the 1090ES ADS-B transponder should send State Vector (SV), Mode Status (MS), Target state (TS), Air Reference Velocity (ARV) Reports, and support the following DAPs capabilities:

- i. airborne position (BDS 0,5).
- ii. Surface Position (BDS 0,6).
- iii. Aircraft Identification and Category (BDS 0,8).
- iv. Airborne Velocity (BDS 0,9).
- v. Aircraft Status (BDS 6,1).
- vi. Target State and Status (BDS 6,2).
- vii. Aircraft Operational Status (BDS 6,3).

3) RTCA DO-260B/EUROCAE ED-102A (Version 2)

The International Civil Aviation Organization issued "Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)" (DO-260B/ED-102) in December 2009, and was known as ADS-B version 2. The formats and protocols for 1 090 ES Version 2 were revised based on experience gained from operational usage with ADS-B that revealed a number of needed improvements, which included:

- i. separated reporting of source and system integrity.
- ii. additional levels of NIC to better support airborne and surface applications.
- iii. incorporation of the broadcast of the Mode A code into the emergency/priority message, increased transmission rates after a Mode A code change, and the broadcast of the Mode A code on the surface.
- iv. revision to the target state and status message to include additional parameters.
- v. eliminated the vertical component of NIC and NAC.
- vi. T = 0 position extrapolation accuracy changed from within 200 ms of the time of transmission to within 100 ms; and
- vii. capabilities were added to support airport surface applications.

According to D0-260B/ED-102A, the 1090ES ADS-B transponder should send State Vector (SV), Mode Status (MS), Target State (TS) and Air Reference Velocity (ARV) Reports, and support the following DAPs capabilities:

- i. Airborne Position (BDS 0,5).
- ii. Surface Position (BDS 0,6).
- iii. Aircraft Identification and Category (BDS 0,8).
- iv. Airborne Velocity (BDS 0,9).
- v. Aircraft Status (BDS 6,1).
- vi. Target State and Status (BDS 6,2).
- vii. Aircraft Operational Status (BDS 6,5).

7.3 Extract Mode S SSR DAPs using a MODE S Interrogator

7.3.1 Working Principles

The Mode S interrogator transmits interrogation to elicit replies for detection of Mode S transponders and more information from the aircraft. The use of a unique ICAO 24-bit aircraft address and provision of all the required aircraft data in one reply will reduce interrogation rates.

Each aircraft can be interrogated selectively, needing only one or two ‘hits’ per aircraft per scan and minimizing interference problems associated with SSR Mode A/C.

The operation of a Mode S interrogator will not interfere with the SSR performance of any aircraft equipped with a Mode A/C transponder.

A Mode S interrogator is capable of performing the conventional surveillance function with Mode A/C transponders.

7.3.2 Interrogator Codes

The Mode S system requires each interrogator to have an IC, which can be carried within the uplink and downlink transmissions. The 4-bit IC uplink field in UF11 shall contain either 4-bit II code or the lower 4

bits of the 6-bit SI codes. It is recommended that whenever possible an interrogator should operate using a single interrogator code.

The II codes shall be assigned to interrogators in the range from 0 to 15. The II code value of 0 shall only be used for supplementary acquisition. The SI codes shall be assigned to interrogators in the range from 1 to 63. The SI code value of 0 shall not be used.

The assignment of interrogator II or SI codes, where necessary in areas of overlapping coverage, across international boundaries of flight information regions, shall be the subject of regional air navigation agreements. The ICAO Asia Pacific Regional Office maintains a register of II codes used – where States have provided this information to the office. States are encouraged to provide this information to the Regional Office and update it when changes are made.

7.3.3 Mode Interlace Pattern

The particular air traffic and environment of each interrogator will influence the selection of suitable interrogation periods, interrogation repeat frequency, MIP and Probability of Reply.



Figure.7-1 The Typical MIP

The repetition frequency and duration of the All-Call period is a local implementation issue (the stated ICAO maximum is 250Hz). The exact duration of either period will depend on the characteristics of the system such as the antenna revolution rate, the beam-width and the maximum range. There will normally be several all-call periods (and hence roll-call periods as one will always follow the other) available to interrogate all targets in range during one revolution.

There is a careful balance between the reliable acquisition of all targets and the potential of flooding the RF environment with unwanted replies to acquisition interrogations. It is necessary to choose an appropriate Mode Interlace Pattern to manage the acquisition activities to ensure minimal interference. The default objective is to define a MIP which effectively detects and performs surveillance on classical SSR Mode A/C aircraft using Mode A/C interrogations which also detects and acquires Mode S aircraft using Mode S interrogations. The MIP is constructed in order to separate Mode A/C and Mode S all-calls from Mode S selective (roll-call) activity. MIP defines the sequences of all-call interrogation types that might be made during cycles of all-call periods. Every interrogator is likely to have different needs and hence different ways of operating.

China presented an IP about the Mode S Parameter Set during the 3rd meeting of DAPs WG. For detailed information please refer to Appendix 4.

7.3.4 Mode S SSR DAPs Extraction using GICB Protocol

The GICB procedure is initiated by a Mode S interrogator for eliciting the Mode S DAPs containing aircraft derived data from a Mode S aircraft installation.

The GICB protocol allows for the immediate transfer of data required by the ground and the extraction of information stored in the Mode S transponder. This information (if available) is contained in the reply to an interrogation specifying the address (BDS code) of the storage location containing that information.

The interrogation with specific BDS can elicit the corresponding Comm-B data where contained in Mode S transponder's registers. The Mode S DAPs can be implemented in two stages: ELS and EHS.

The first processing step for any Mode S data link application is to obtain the transponder CA value from the aircraft. The 3-bit CA field is found in the "Mode S All-Call Reply" (DF=11) and the "Extended Squitter" (DF=17) downlinks. If CA=0, then this transponder is surveillance-only and supports no data link functions at all. If $CA \geq 4$ indicates that the Mode S transponder is fully capable of at least 56-bit short uplink and downlink message transfer. These Mode S transponders may support the ELS, EHS requirements. The values of CA= 1, 2, 3 are reserved.

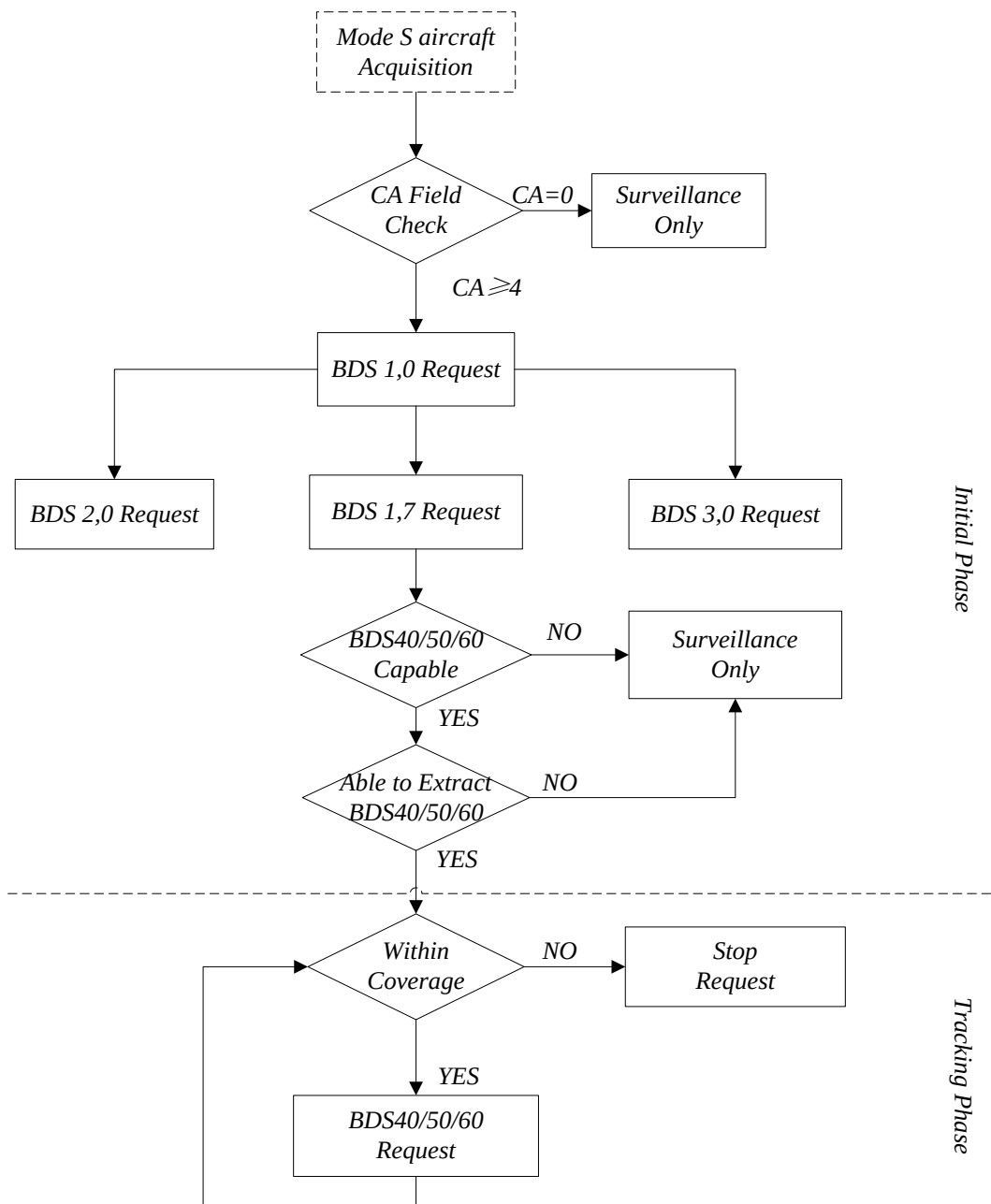


Figure.7-2 The Typical Procedure of DAPs Extraction

Given that the Mode S transponder's CA value is 4 or greater, the second processing step for any Mode S data link application is to extract the transponder's Mode S data link capability report register BDS code

1,0. Bits in this register indicate the support of such Mode S data link functions as aircraft identification (register BDS code 2,0), ACAS (register BDS code 3,0), common-usage capability (register BDS code 1,7) etc. The Mode S-Specific services capability bit in register BDS code 1,0 indicates whether the avionics installation supports further data link functions. If this bit is set, the Mode S data link application would next extract the common-usage capability register BDS code 1,7. All of the registers involved with the EHS application have bit flags assigned in this register BDS code 1,7. If the bit flag is set, it indicates that the corresponding register has been updated in a timely manner and contains valid data which can be extracted by the interrogator. The processing protocol is sufficient initialization for basic data link applications such as ELS, EHS since all their status and configuration information is available from register BDS code 1,0 and register BDS code 1,7.

So, the Mode S interrogator should transmit the selective interrogation to elicit the Mode S transponder reply with the specific formats and Comm-B data contained in the corresponding registers.

Normally, the more Comm-B data requested by the Mode S interrogator, the more information can be extracted from the aircraft transponder registers. It will also help the ATC controller get the aircraft's flight status and flight intention. However, there should be some necessary limitations for the Comm-B data request to avoid the phenomenon of Comm-B data discontinuity because of the limited Roll-Call interrogation duration.

It is suggested that the number, periodicity and priority of BDS data extraction rule be reasonably and effectively implemented according to the requirements and the number of aircraft in the airspace. The scientific strategy can ensure the ATC controller gets Comm-B data timely and effectively.

7.3.5 Mode S SSR DAPs Extraction using AICB Protocol

The AICB procedure is initiated by a Mode S transponder for transmitting a single Comm-B segment from the aircraft installation.

Any changes in the contents of ACAS (register BDS code 3,0) triggers a downlink message via the air-initiated Comm-B broadcast protocol including the updated register contents.

An AICB sequence shall start upon the acceptance of a message intended for delivery to the ground sensor. After receipt of this message, the transponder shall set a valid downlink request code of surveillance or Comm-B reply. On receipt of this message with a valid downlink request code, the interrogator could start to extract the message.

AICB messages are announced by the transponder and are transmitted in a subsequent reply only after authorization by the interrogator. AICB messages are announced to all interrogators and can be extracted by any interrogator. The Mode S data link application should update the aircraft's "state" values with the new ones. The changed state might result in discontinuance (or reinstatement) of certain Mode S data link functions. Mode S transponder AICB broadcast messages are held active in the transponder for 18 seconds after the triggering event. Any Mode S sensor can extract the broadcast information.

7.3.6 Mode S SSR DAPs Extraction using Comm-B Broadcast

A Comm-B broadcast is a message directed to all active interrogators in view. Messages are available for 18 seconds unless a waiting AICB interrupts the cycle. Interrogators have no means to cancel the Comm-B broadcast.

Currently, only registers of datalink capability report (register BDS code 1,0) and aircraft identification (register BDS code 2,0) make use of the Comm-B Broadcast.

7.3.7 Error Protection

An error may occur in the reception of an interrogation or a reply. Mode S interrogations and replies use cyclic polynomial methods to detect errors. A sequence of 24 parity check bits shall be generated by a modulo-2 division of the content of the message by a generator polynomial. The content of the message is bits $(m_1, m_2, \dots, m_k)$ where k is 32 for short transmission or 88 for long transmission. The generator polynomial is $G(x) = 1 + x^3 + x^{10} + x^{12} + x^{13} + x^{14} + x^{15} + x^{16} + x^{17} + x^{18} + x^{19} + x^{20} + x^{21} + x^{22} + x^{23} + x^{24}$.

At the encoder, the content sequence appends 24 zero bits is divided by $G(x)$ to result a remainder.

At the ground station encoder, the remainder is uplinked in the AP field. It shall be modulo-2 added with the most significant 24 bits of the 48-bit sequence generated by multiplying $A(x)$ by $G(x)$, where $A(x)$ is the aircraft address sequence or 24 one bits.

At the transponder encoder, the remainder is downlinked in the AP field of DF0/4/5/16/20/21/24, or in the PI field of DF11/17/18. The AP field shall contain the remainder overlaid on the aircraft address. The PI field shall have the remainder overlaid on the interrogator's identity code. If the reply is made in response to a Mode A/C/S all-call, a Mode S-only all-call with CL field and IC field equal to 0. If it is an acquisition or an extended squitter, the II and the SI codes shall be 0.

At the ground station decoder, the whole transmission is divided by the same generator polynomial. If the received message is one of DF0/4/5/16/20/21/24, the remainder is added (compare) to the expected 24-bit aircraft address to produce the error syndrome. If the syndrome is ALL ZEROs, an error-free message was received. If the syndrome is non-zero, a single error or error burst is present. The error correction procedure uses the message bit sequence, the initial error syndrome and the confidence bit sequence. # NOTE: For more detailed information please refer to *ICAO Doc 9924 Aeronautical Surveillance Manual (Third Edition 2020)*, Appendix G: Mode S Error Detection and Correction.

7.4 Provision of ADS-B DAPs using extended squitter

7.4.1 Working Principles

The “1090 Extended Squitter” is a spontaneous broadcast transmission by the Mode S transponder on the 1090 MHz frequency not initiated by an interrogation on 1030 MHz. The “Automatic Dependent Surveillance – Broadcast (ADS-B)” is a function of airborne or surface aircraft, or other surface vehicles operating in the airport surface area, that periodically transmits its state vector (horizontal and vertical position, horizontal and vertical velocity) and other information via a data link.

The 1090 Extended Squitter allows the transmission of ADS-B messages by means of 1090 Extended Squitter via 1090 MHz. The ADS-B message is formatted data that conveys information used in the development of ADS-B reports that can be used for air traffic management activity. The ADS-B reports can support improved use of airspace, surface surveillance, and enhanced safety such as conflict management.

There are four defined standards for the ADS-B 1090 ES applications. These standardizations were consistent with RTCA/DO-260, RTCA/DO-260A, RTCA/DO-260B and RTCA/DO-260C were termed 1090 ES Version 0, Version 1, Version 2 and Version 3. (1090 ES Version 3 has just been released in December 2020.)

The differences between the first three versions are mainly in the following two areas: (a) its specification of the ADS-B “event driven” transponder register set, and (b) how available avionics surveillance accuracy is specified.

7.4.2 ADS-B Message content

The Mode S transponder has 255 BDS registers. Each register stores aircraft parameters, message or data derived from FMS or other sensors. Some specific registers are defined for the ADS-B application so that related messages can be delivered via ADS-B message broadcast activity.

Table 7-2 Registers Related to ADS-B Application

Register	Content		
BDS code 0,5	Version0	Version1	Version2
	Airborne Position Message		
	Single Antenna Flag		NIC Supplement-B
	Airborne Position		
	Pressure Altitude		
	GNSS Height		
	Surveillance Status		
BDS code 0,6	Version0	Version1	Version2
	Surface Position Message		
	Ground Track	Heading	
	Surface Position		
	Movement		
BDS code 0,8	Version0	Version1	Version2
	Aircraft Identification and Type Message		
	Aircraft Category		
	Aircraft Identification		
BDS code 0,9	Version0	Version1	Version2
	Airborne Velocity Message		
	NUC _R	NAC _v	
	IFR Capability Flag		-
	Subtypes 1 and 2:Velocity Over Ground		Subtypes 3 and 4:Airspeed and Heading
	Ground Speed Vector		Air Speed
			Heading
	Intent Change Flag		
	Ground Speed Vector		
	Vertical Rate		
	Difference from Baro Altitude		
BDS code 6,1	Version0	Version1	Version2
	Aircraft Status Message		
	Subtype 1:Emergency/Priority Status		Subtype 2:1090ES TCAS RA Broadcast
	Emergency Status		ACAS RA Report
	-		
BDS code 6,2	Version 0	Version 1	Version 2

	Current/Next Trajectory Change Point(TCP) Message	Target State and Status Information Message	
	TCP data	Target Altitude	Selected Altitude
		-	SIL Supplement
			Barometric Pressure Setting
		Track Heading / Track Angle	Selected Heading
		Emergency/Priority Status	Mode Engaged (Autopilot VNAV Altitude Approach LNAV)
		Capability/Mode Code	TCAS Operational
		NAC _P 、SIL、NIC _{BARO}	
BDS code 6,3	Version 0	Version 1	Version 2
	Current/Next Trajectory Change Point Message(TCP+1)	Aircraft Operational Status Message	
	TCP+1 Data	Subtype 0	Subtype 1
		Airborne Capability Class	Surface Capability Class
			Length/Width Codes
		NIC _{BARO}	TRK/HDG
		Operational Mode OM	
		Version Number	
		NIC Supplement	
		NAC _P 、SIL	
		HRD	
BDS code 6,4	Version 0	Version 1	Version 2
	Aircraft Operational Coordination Message	-	
	Paired Address	-	
	Runway Threshold Speed		
	Roll Angle		
BDS code 6,5	Version 0	Version 1	Version 2
	Aircraft Operational Status Message	-	Aircraft Operational Status Message
	CC	-	Subtype = 0
			Subtype = 1
			Airborne Capability Class
			Length/Width
		Airborne Operational Mode	Surface Operational Mode

	OM		GVA	-
			NIC _{BARO}	TRK/HDG
			Version Number	
			NIC Supplement-A	
			NAC _P , SIL	
			SIL Supplement	
			HRD	

As shown in the above table, all the versions of 1090 ES application involve the 7 basic registers (Airborne Position, Surface Position, ES Status, ES Identification and Category ES Airborne Velocity ES Event Driven Register and ES Aircraft Status). The remaining registers (BDS code 6,2, BDS code 6,3, BDS code 6,4) in the table have different definitions and applications for the three versions of 1090 ES application. Generally, for version 0, only five registers (BDS code 0,5, code 0,6, code 0,8, code 0,9 and BDS code 6,1) will be broadcast. In addition to the above five registers, version 1 will also broadcast message about BDS code 6,2 and code 6,3, while version 2 will broadcast message about BDS code 6,2 and code 6,5 additionally.

Table 7-3 ADS-B Message

Version	Common usage ADS-B Message
0,1,2	ES Airborne Position
	ES Surface Position
	ES Identification and Category
	ES Airborne Velocity
	ES Aircraft Status / Type Code=28
1,2	Target State and Status Information / BDS code 6,2/Type Code=29
1	Aircraft Operational Status / BDS code 6,3/Type Code=31 for version 1
2	Aircraft Operational Status /BDS code 6,5/Type Code=31 for version 2

The three versions of the ADS-B application have different definitions of surveillance accuracy and the application of “event-driven” register messages. Therefore, the prerequisite for the correctly decoding the surveillance accuracy information and “event-driven” messages is the determination of the 1090 ES version.

There are two steps to check the ADS-B version, due to the fact that ADS-B version information in version 0 is not included in any message. **Step 1:** Check whether an aircraft is broadcasting ADS-B messages with Aircraft Operational Status message (Type Code=31) at all. If no message is ever reported, it is safe to assume that the version is equal to “0”. **Step 2:** If messages with Type Code =31 are received, check the version numbers located in the bits 41–43 in ME (or bits 73–75 in the message). The bits “001” correspond to version 1 and “010” to version 2 respectively.

7.4.3 ADS-B message Transmission Broadcast rate

The maximum ADS-B Message transmission rate shall not exceed 6.2 transmitted messages per second averaged over any 60 second interval. **There are periodic messages which are broadcast in the periodic manner and event-driven messages which are broadcast following the event-driven protocol. The event-driven protocol limits event-driven message transmissions to 2 per second in any second.**

- a) **Airborne position Message (Version 0, 1, 2) is a periodic message, and shall be emitted at**

random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds.

b) **Surface position Message (Version 0, 1, 2)** is a periodic message, and shall be emitted using one of two rates (high or low rate). The low rate is used when the aircraft is stationary, the high rate is used when the aircraft is moving. When the high squitter rate has been selected, the transmission interval of the surface position message obeys a uniform distribution within the interval of 0.4 to 0.6 seconds, and when the low squitter rate is used, it shall be emitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds.

c) **Aircraft identification Message (Version 0, 1, 2)** is a periodic message, which transmission interval follows a uniform distribution over 4.8 to 5.2 seconds when the aircraft is reporting the airborne position message, or when the aircraft is reporting the surface position message at the high rate (moving). When the surface position message is being broadcasted at the low rate (stationary), the message shall be emitted at random intervals that are uniformly distributed over the range of 9.8 to 10.2 seconds.

d) **Airborne velocity Message ((Version 0, 1, 2)** is a periodic message, and shall be emitted at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds.

e) **Target State and Status Message (Version 1, 2)** is delivered using the event-driven protocol in version 1 and is periodic message in version 2, and shall be initiated only when the aircraft is airborne and when target state (vertical or horizontal) information is available and valid. The TSS Message shall be broadcast at random intervals with the uniformly distributed over the range of 1.2 to 1.3 seconds.

f) **Aircraft Operational Status Message –Airborne** is delivered using the event-driven protocol in version 1 and is periodic message in version 2, and shall be emitted for a period of 24 seconds at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds, when the Target State and Status (TSS) Message is not being broadcast and there has been a change within the past 24 seconds in the value of one or more of the specific parameters (*TCAS Operational/TCAS RA Active/NACP/SIL for Version 1 and TCAS RA Active/NACP/SIL/NIC_{SUPP} for Version 2*) included in the Operational Status Message.

For other case when there is not any change within the past 24 seconds in the value of the specific parameters mentioned previous paragraph, the transmission interval of the message obeys a uniform distribution within the interval of 2.4 to 2.6 seconds.

g) **Aircraft Operational Status Message –Surface** is delivered using the event-driven protocol in version 1 and is periodic message in version 2, and shall be always broadcast at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds for **Version 1**. For **Version 2**, the Surface Aircraft Operational Status Messages shall be broadcast at random intervals that are uniformly distributed over the range of 4.8 to 5.2 when the aircraft is on-ground and not moving. If the Aircraft is moving and there has been no change in the specific parameters (*NIC_{SUPP} / NAC / SIL*) then the message shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds for Version 2. When the Version 2 aircraft is on-ground and moving and there has been a change in the parameters mentioned above then the message shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds.

h) **Extended Squitter Aircraft Status message (Version 0)** is an event-driven message, and shall be broadcast at random intervals that are uniformly distributed over the range of 0.8 to 1.2 seconds for the duration of the emergency condition (temporary or permanent). If the Mode A Code is changed to 7500, 7600 or 7700, the duration of emergency condition shall be permanent. If the Mode A Code is changed to any other value, the emergency condition shall be temporary, and duration is equal to 18 seconds (TC).

i) **Extended Squitter Aircraft Status message (Version 1)** is an event-driven message, and the

transmission rate varies depending on whether the TSS Message is not being broadcast, versus being broadcast.

In the case where the TSS Message is not being broadcast, the Extended Squitter Aircraft Status message shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds for the duration of the emergency condition. It shall be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds for the duration of the emergency condition, when the TSS Message is being broadcast.

j) **Extended Squitter Aircraft Status message with Subtype=1 (Version 2)** is an event-driven message, and shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds for the duration of the emergency condition, or the Message shall not be broadcast (no emergency condition established), When the Mode A Code transmission is disabled (be set to Mode S Conspicuity Code “1000”).

When the Mode A Code transmission is enabled, the Aircraft Status message with Subtype=1 shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds for a duration of 24 ± 1 seconds following a Mode A Code change by the pilot.

In the absence of conditions above for version 2, the Message shall be broadcast at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds.

The Aircraft Status Message with Subtype=2 (TCAS RA Broadcast) for version 2 shall be broadcast at random intervals that are uniformly distributed over the range of 0.7 to 0.9 seconds. The transmission shall be terminated 24 ± 1 seconds after the *Resolution Advisory Termination* (RAT) flag transitions from ZERO (0) to ONE (1).

7.5 Application of the Mode S DAPs in ATM Automation System

7.5.1. Implementation of the General DAPs information

General DAPs information refers to the information that both Mode S SSR, MLAT and ADS-B can provide. This information from aircraft can be beneficial to the ATM automation system:

- a) ICAO 24-bit Aircraft Address/Aircraft Identification
 - 1) The ATM automation system should collect the real aircraft address/aircraft identification from the received message, and the aircraft address/aircraft identification can be shown on the control HMI to identify the aircraft.
 - 2) The ATM automation system can use the aircraft address/aircraft identification to correlate an aircraft's track with the flight plan, so the use of aircraft address/aircraft identity can alleviate the shortage of Mode 3/A code. Correlation between track and flight plans is normally based on either the 24-bit aircraft address, aircraft identification, or the Mode 3/A code. The correlation will depend on their weights and priority.
 - 3) The ATM automation system can also utilize the aircraft address/aircraft identification to improve the tracking function.
 - 4) The ATM automation system could provide DUPE warning between aircrafts which have the same ICAO 24-bit aircraft address, same aircraft identification or the same Mode 3/A code.
- b) Altitude reporting in 25ft interval

The ATM automation system can collect aircraft altitude reporting in 25ft increments and provides valuable improvements to the quality of safety nets. The improvements should reduce the number of nuisance alerts and enhance the integrity of separation assurance.

c) Selected Altitude

- 1) The ATM automation system can collect the selected altitude of the aircraft from Mode S SSR DAPs BDS 4,0 or ADS-B DAPs BDS 6,2 (Version 2) that can be shown to the controller to improve the situational awareness of the controller.
- 2) The ATM automation system can generate a SFL Mismatch Alarm when the SFL chosen by the crew does not match the cleared altitude given by the controller (CFL), alerting the controller to take appropriate action to remedy the issue. A SFL Mismatch Alarm shall be presented to the responsible controller as an indication in the coupled/correlated surveillance track label and in the associated flight strip.
- 3) The ATM automation system can also utilize the SFL to improve the accuracy of the safety net.

In MTCD function, the ATM automation system can use the selected altitude as the target climbing/descending altitude in the flight look-ahead time, and calculate the possibility of conflict with the predicted flight trajectories of other flights in the airspace through trajectory prediction. Calculations involving SFL could be more accurate, and improve the performance of MTCD.

In MSAW function, the ATM automation system generally provides MSAW warning by using track data (heading and rate of climb/descent and mode c). The ATMs use of CFL or SFL can enhance the MSAW algorithms use of vertical data to predict MSAW alerts and reduce the number of false alerts.

It is important to note that, in a given situation, there is a possibility of inconsistency between the selected altitude and the target height indicating the actual vertical intent. When using the selected altitude for prediction and warning, we still need to continuously monitor whether the actual trajectory is consistent with the selected altitude.

d) Barometric Pressure Setting

The ATM automation system can collect the barometric data of the aircraft from Mode S SSR DAPs BDS 4,0 or ADS-B DAPs BDS 6,2 (Version 2) and provide this information to the controller. The system can provide a warning when the barometric data transmitted by the aircraft does not match the parameter of the area where the aircraft is operating.

e) Ground Speed, True Track Angle, Magnetic Heading, True Airspeed

- 1) The ATM automation system can collect Ground Speed, True Track Angle from Mode S SSR DAPs BDS 4,0 or ADS-B DAPs BDS 0,9 and 0,6, True Airspeed from Mode S SSR DAPs BDS 5,0 or ADS-B DAPs BDS 0,9 (if ground speed is unavailable), Magnetic Heading from Mode S SSR DAPs BDS 6,0 or ADS-B DAPs BDS 0,9 (if ground speed is unavailable). The system may provide the display of some of the information to the controller to improve the situational awareness of the controller. This information can be displayed in various ways (e.g., a DAP Window) as offline defined, according to the requirement of the controllers. Display of some parameters provides a clearer picture to the controllers generating a reduction in radio calls with the pilot, so the R/T usage between the controller and individual aircraft under service is reduced.
- 2) The system can make use of DAPs kinematics parameters for consistency checking, and perform a more precise tracking function.

- 3) The system can utilize the kinematics information of the aircraft to improve the accuracy of safety net functions, (e.g., Short-Term Conflict Alert (STCA)), through the provision of more accurate aircraft tracks.
- 4) The system may use True track angle, Magnetic Heading, True Airspeed and Ground Speed to calculate a wind direction and speed of a specific area, which will enable the updating of forecast winds and improve trajectory modeling in the system. The system may also show the wind information to the controller to improve the situational awareness of the controller.

f) Barometric Altitude Rate

The ATM automation system can collect the vertical rate data of the aircraft from Mode S SSR DAPs BDS 4,0 or ADS-B DAPs BDS 0,9 to improve the precision of the compute altitude and the accuracy of the related alert. The system can make use of the data to realize an optimized CFL protection in STCA and MSAW analysis function.

g) Indicated Air Speed

The ATM automation system can acquire indicated airspeed of the aircraft from Mode S SSR DAPs BDS 6,0 or ADS-B DAPs BDS 0,9 (if ground speed is unavailable), allow ATC to monitor the aircrew compliance with the controller's instructions, and if required provide a warning to the controller when there is a mismatch.

h) ACAS Resolution Advisory Report

Some of the ATM automation system can collect the ACAS Resolution Advisory Report from Mode S SSR DAPs BDS 3,0 or ADS-B DAPs BDS 6,5 (Version 2). The ACAS Resolution Advisory information can be shown in the system to improve situational awareness of the controller. On receipt of ACAS Resolution Advisory notification, a prominent notification is displayed in a field that may be acknowledged. The indication is removed when the ACAS RA is resolved.

Note: The display of ACAS Resolution Advisory Report in ATM automation system can be turned on or turned off by a user, and it's use if not recommended by IFATCA. The user is suggested to do the relevant safety evaluation before applying this function.

7.5.2. Mode S SSR DAPs

Mode S SSR DAPs information refers to the information that only Mode S SSR can provide. This following information of aircraft can be beneficial to the ATM automation system:

a) Roll Angle, Track Angle Rate,

- 1) The ATM automation system can collect these parameters from Mode S SSR DAPs BDS 5,0 and may allow the display of some of the information to the controller to improve the situational awareness of the controller. This information can be displayed in various ways (e.g., a DAP Window) as offline defined, according to the requirement of the controllers. Display of some parameters provides a clearer picture to the controllers generating a reduction in radio calls with the pilot, so the R/T usage between the controller and individual aircraft under service is reduced.
- 2) The system can make use of DAPs kinematics parameters for consistency checking, and perform a more precise tracking function.
- 3) The system can utilize the kinematics information of the aircraft to improve the accuracy of safety net functions, (e.g., Short-Term Conflict Alert (STCA)), through the provision of more accurate aircraft tracks.
- 4) The system may use True track angle, Magnetic Heading, True Airspeed and Ground Speed to calculate a wind direction and speed of a specific area, which will enable the updating of

forecast winds and improve trajectory modeling in the system. The system may also show the wind information to the controller to improve the situational awareness of the controller.

b) Inertial Vertical Velocity

The ATM automation system can acquire the vertical rate data of the aircraft from Mode S SSR DAPs BDS 6,0 to improve the precision of the compute altitude and the accuracy of the related alert. The system can make use of the data to realize an optimized CFL protection in STCA and MSAW analysis function.

c) Mach Number

The ATM automation system can acquire Mach number of the aircraft from Mode S SSR DAPs BDS 6,0. This information can allow ATC to monitor the aircrew compliance with the controller's instructions, and if required provide a warning to the controller when there is a mismatch.

d) Flight status (airborne/on the ground)

The ATM automation system can collect the flight status of the aircraft from reply of the Mode S SSR Roll-Call interrogation. Whether the aircraft is airborne or on the ground can be shown in the system to improve the situational awareness of the controller. Also, the flight status can be used to filter the aircraft on the ground in the system if necessary.

7.5.3. ADS-B DAPs

a) Aircraft emitter category

The emitter category can be acquired from ADS-B DAPs BDS 0,8 can be provided information about the type of vehicle to the controller by the ATM automatic system. The system can provide a warning to the controller when the information transmitted by the aircraft does not match the Flight Plan.

b) GNSS information (latitude, longitude, height, altitude, velocity, vertical rate, accuracy and integrity of GNSS information)

- 1) The precision of aircraft position in GNSS information should be higher than normal radars. The ATM automation can make use of DAPs GNSS information to perform a more precise tracking function.
- 2) The ATM automation system can utilize the GNSS information in different ways or display in different symbols to the controller based on the accuracy and integrity values of current GNSS information received in the messages.
- 3) In order to meet the requirements of ICAO Annex 6 and Annex 10 for aircraft RVSM altitude maintenance performance monitoring, the geometric altitude in ADS-B (using as the real altitude of aircraft operation), can be compared with the air pressure altitude (Mode C) to analyzes the aircraft altitude keeping performance. The comparison verifies whether the aircraft is flying according to the selected altitude setting by the crew, and validates the continual compliance for RVSM altitude monitoring.
- 4) Airborne horizontal position/Geometric altitude can be used in data analysis. Based on flight trajectory, an analyzer can classify different trajectory models, view different traffic pattern, find abnormal trajectory, analyze the operation efficiency of traffic flow, and predict the flight time of future trajectory.

c) Selected Heading/Target Heading

- 1) The ATM automation system can use the selected heading/target heading of the aircraft, and may display the information to the controller to improve the situational awareness of the controller.
- 2) The ATM automation system can generate a heading Mismatch Alarm when the selected heading/target heading does not match the heading given by the controller, alerting the controller to take appropriate action to remedy the issue.
- 3) The ATM automation system can also utilize the selected heading/target heading to improve the accuracy of the safety net.

7.6 Flight Planning

7.6.1 ICAO Flight Plan Item 7 - Aircraft Identification

ACID must be accurately recorded in item 7 of the ICAO Flight Plan form as per the following instructions:

Aircraft Identification, not exceeding 7 alphanumeric characters and without hyphens or symbols is to be entered both in item 7 of the flight plan and replicated exactly when set in the aircraft (for transmission as Flight ID) as follows:

Either,

- a) The ICAO designator for the aircraft operating agency followed by the flight identification (e.g., KLM511, NGA213, JTR25), when in radiotelephony the call sign to be used by the aircraft will consist of the ICAO telephony designator for the operating agency followed by the flight identification (e.g., KLM 511, NIGERIA213, JESTER25).

Or,

- b) The nationality or common mark registration marking of the aircraft (e.g., EIAKO, 4XBCD, N2567GA), when:
 - 1) in radiotelephony the callsign used by the aircraft will consist of this identification alone (e.g., CGAJS), or preceded by the ICAO telephony designator for the operating agency (e.g., BLIZZARD CGAJS),
 - 2) the aircraft is not equipped with a radio.

Note 1: No zeros, hyphens, dashes or spaces are to be added when the Aircraft Identification consists of less than 7 characters.

Note 2: Appendix 2 to ICAO DOC4444 (PANS-ATM 16th edition, 2016) refers.

Note 3: Standards for nationality, common and registration marks to be used are contained in Annex 7, section 3.

Note 4: Provisions for the use of radiotelephony call signs are contained in Annex 10, Volume II, Chapter 5. ICAO designators and telephony designators for aircraft operating agencies are contained in Doc 8585 — Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services.

7.6.2 Equipment (Surveillance Equipment /SSR Equipment)

- a) ICAO Flight Plan Item 10 – Surveillance Equipment and Capabilities

When an aircraft is equipped with a Mode S Transponder, appropriate Mode S designators shall be entered in item 10 of the flight plan to indicate that the flight is capable of transmitting Mode S DAPs messages.

These are defined in ICAO DOC 4444 as follows:

‘N’ No surveillance equipment for the route to be flown is carried, or the equipment is unserviceable

SSR Mode A and C

‘A’ Mode A transponder

‘C’ Mode A and Mode C transponder

SSR Mode S

‘E’ Mode S transponder, including aircraft identification, pressure-altitude and extended squitter (ADS-B) capability

‘H’ Mode S transponder, including aircraft identification, pressure-altitude and enhanced surveillance capability

‘I’ Mode S transponder, including aircraft identification, but no pressure-altitude capability

‘L’ Mode S transponder, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability

‘P’ Mode S transponder, including pressure-altitude, but no aircraft identification capability

‘S’ Mode S transponder, including both pressure altitude and aircraft identification capability

‘X’ Mode S transponder with neither aircraft identification nor pressure-altitude capability

Note: Enhanced surveillance capability is the ability of the aircraft to down-link aircraft derived data via a Mode S transponder.

b) ICAO Flight Plan Item 18 – Other Information

Where required by the appropriate authority the ICAO AA (24 Bit Code) may be recorded in Item 18 of the ICAO flight plan, in hexadecimal format as per the following example:

CODE/7C432B

Members or states should note that use of hexadecimal code may be prone to human error and is less flexible in regard to airframe changes for a notified flight.

7.6.3 Inconsistency between Mode S Flight Planning and Surveillance Capability

Inconsistency between flight planning of Mode S and surveillance capability of an aircraft can impact ATC planning and situational awareness. States are encouraged to monitor for consistency between flight plan indicators and actual surveillance capability. Where discrepancies are identified aircraft operators should be contacted and instructed to correct flight plans, or general advice (as appropriate to the operational environment and type of flight planning problems) should be issued to aircraft operators.

Advice to Operators:

Concerning inconsistency between Mode S Flight Planning and Surveillance Capability:

- a) ICAO AA (24 Bit Code) not submitted, or submitted incorrectly.

- b) Mode S and surveillance capabilities indicators incorrectly.

The flight planning requirements and relevant designators for aircraft are described in local document reference or ICAO DOC 4444 Appendix 2. The capability of the aircraft transponder and ADS-B capability will typically be available in the transponder manual or the aircraft flight manual for the aircraft. If in doubt, consult the transponder manual, aircraft flight manual or the Licensed Aircraft Maintenance Engineer.

7.6.4 Setting Flight ID in Cockpits

- a) Flight ID Principles

The Flight ID is the equivalent of the aircraft callsign and is used in both Mode S SSR and ADS-B technology. Up to seven characters long, it is usually set in airline aircraft by the flight crew via a cockpit interface. It enables air traffic controllers to identify an aircraft on a display and to correlate a radar or ADS-B track with the filed flight plan ACID. Flight ID is critical, so it must be entered carefully. Punching in the wrong characters can lead to ATC confusing one aircraft with another.

The Flight ID entered in the transponder exactly must match the ACID entered in the flight plan.

Intuitive correlation between an aircraft's flight identification and radio callsign enhances situational awareness and communication. Airlines typically use a three letter ICAO airline code in flight plans, NOT the two letter IATA codes.

- b) Setting Flight ID

The callsign dictates the applicable option below for setting Mode S or ADS-B Flight ID:

- 1) The flight number using the ICAO three-letter designator for the aircraft operator if a flight number callsign is being used (e.g., QFA1 for Qantas 1, THA54 for Thai 54).
- 2) The nationality and registration mark (without hyphen) of the aircraft if the callsign is the full version of the registration (e.g., VHABC for international operations).
- 3) The registration mark alone of the aircraft if the callsign is the abbreviated version of the registration (e.g., ABC for domestic operations).
- 4) The designator corresponding to a particular callsign approved by the ANSP or regulator (e.g., SPTR13 for firepotter 13).
- 5) The designator corresponding to a particular callsign in accordance with the operations manual of the relevant recreational aircraft administrative organization (e.g., G123 for Gyroplane 123).

Note: More information of Flight plan for 1090 MHz ADS-B can refer to section 9.10 of AIGD.

7.7 Contingency Plan

ANSPs should prepare appropriate contingency plans in the event of a system failure that prevents the use of Mode S DAPs.

8. TRAINING AND COMPETENCY

8.1 Introduction

Training and development play an important role in the effectiveness of organizations and to the experiences of people in work. Training on DAPs has implications in improving productivity, aviation safety and personal development. The primary goal of the training is to develop and maintain an appropriate level of trust in DAPs related module, i.e., to make ATC and ATSEP aware of the likely situations where DAPs will be effective and, more importantly, situations in which DAPs will not be so effective (e.g., sudden, unexpected maneuvers).

8.2 Training of an Air Traffic Controller (ATC) in DAPs

With the inclusion of DAPs into surveillance and ATM automation system, an ATC training plan should adopt a modular approach. This approach progressively introduces various features, functionality of the new system on one hand and allows for integration with the ATC operational procedures. Additional benefits include shorter, logical self-contained units, clear attainable goals, better evaluation of training effectiveness and simplified self-assessment.

The ANSP should develop familiarization and rating focused training to ATC prior to adoption of DAPs in Surveillance and ATM automation systems.

The ANSP should ensure that all ATC concerned are assessed as competent for the use of the relevant DAPs module.

8.3 Training of an ATSEP in DAPs

- a) The ANSP should develop an ATSEP training programme that is acceptable to the ANS Regulator prior to its implementation.
- b) As a minimum, the training programme should comprise three levels as described below:
 - 1) Level 1 (Basic training). This should comprise training on the basic Surveillance and ATM automation systems operating in the State and their impacts on the safety of aircraft operations. The ANSP should ensure every ATSEP undergoes the basic training.
 - 2) Level 2 (Qualification training). This should comprise training to develop knowledge and skills on Surveillance and ATM automation systems. The ANSP should ensure each ATSEP is trained in one or more domains depending on their job scope.
 - 3) Level 3 (Specialized training). This should comprise training on specific Surveillance and ATM automation systems installed in the State, followed by on-the-job training.
- c) The ANSP should conduct a yearly review of the training plan for each ATSEP at the beginning of the year to identify any gaps in competency or changes in training requirements and priorities the type of training required for the coming year in regards of DAPs development.
- d) The ANSP should keep records of individual ATSEP training, competency assessment and approval history, where applicable, and associated documents. The records should be kept at least until the Surveillance and ATM automation system of which the ATSEP was trained on is no longer in use with the ANSP.
- e) The individual training records for each of ATSEP should include a training plan detailing the

courses completed as well as the time-frame for attending future courses as required under his/her training plan.

8.4 Competency Assessment of an ATSEP in DAPs

- a) The ANSP should develop an assessment methodology to determine the competency of an ATSEP in accordance with the competency framework developed in PANS-Training and which should be adapted to suit the local context.
- b) The ANSP may select a person to be a competency assessor only if the person –
 - 1) is an ATSEP approved in accordance with paragraph 8.3 for the particular Surveillance and ATM automation system; and
 - 2) has received adequate training in the conduct of competency assessment, practical checks and oral questionings.
- c) A competency assessor should not conduct a competency assessment on an ATSEP who is under the direct supervision of the competency assessor unless the assessment is done in the presence of a second independent assessor.
- d) The assessment methodology should include a process for on-going competency checking and refresher training to ensure retention of competence.

9. SPECIFIC EXAMPLES ON MODE S DAPs APPLICATION

9.1 Use of Selected Altitude

Since August 2013, Mode S data processing functions have been implemented in Chengdu ATM automation system. The system uses the select altitude data extracted from the Mode S DAPs to provide an optimized CLAM alert for controllers. The system will generate the alert when the SFL chosen by the crew does not match the cleared altitude recorded in the ATM automation system. And a time delay parameter is predefined for the response time of the flight after controllers' input to the ATM automation system (typically at the time of instruction given to the pilot).

Thanks to this new kind of alert, controllers have a better awareness of the intention of the airplanes and may discover the crew's mis-operation much earlier than the traditional CLAM, and then take actions timely to avoid the potential conflict.

In April 2017, an A320 aircraft was maintaining level flight at 27600 feet with another flight flying nearby at 26600 feet. Suddenly, the crew set an error altitude 22600 feet. The ATM automation system triggered the alert immediately even before the aircraft began to descend. The controller quickly noticed the alert and informed the crew in time. The aircraft successfully stopped descend at 27400 feet.

9.2 Use of ACAS RA

With the advancement of the ASTERIX standards and DAPs application, an ATM system can handle the derived data from Aircraft, which is detected, received and transmitted through the Mode S Radar, ADS-B station, and WAM sensors. In the event that an Airborne Collision Avoidance System (ACAS) Resolution Advisory (RA), the ATM system is able to provide a visual and aural alarm warning and indicative pilot intention to the controller.

Resolution Advisory (RA) alerting function works as follows:

- A resolution advisory is present when, in the subfields I048/260, I020/260, I021/260, I021/260 or I062/380 subfield #12(ACS), the bits are set as follows:

- the first bit of the ARA field set to 1 and the RAT bit set to 0 or,
- the first bit of the ARA field set to 0, the MTE bit set to 1 and the RAT bit set to 0.

- A resolution advisory is removed when:

- the ACAS RA report subfield (I048/260, I020/260, I021/260 or I062/380 subfield #12(ACS)) contains the RAT bit set to 1, or
- An ACAS RA report is not received in the relevant Data Item of the ASTERIX report.

Besides, the Resolution Advisory Intention is populated base on the PILOT selection and according to the following table:

MTE (60)	ARA (41)	42	43	44	45	46	47	RA Selection	RA Intention

1	0	Any	0	Any	1	Any	Any	Descend	Positive descend (Descent to avoid the threat)
1	0	Any	1	Any	0	Any	Any	Climb	Positive climb (Climb to avoid the threat)
1	0	Any	0	Any	0	Any	Any	Other	Other

*NOTE1: ACAS Airborne Collision Avoidance System, applied in the EURO Aviation System, has the same meaning as TCAS abbreviated to Traffic Alert and Collision Avoidance System in the USA Aviation System

*NOTE2: The function and the matters needing attention related to ACAS Resolution Advisory Report in ATM automation system, please refer to 7.4.1 e).

9.3 Use of Mode S DAPs data for weather forecast

Meteorological Research Institute (MRI) and Electronic Navigation Research Institute (ENRI) conducted experiments for improving weather forecast accuracy utilizing Mode S DAPs data. In the experiments, horizontal wind and temperature were estimated from the data in registers BDS code 5,0 and BDS code 6,0 listed below.

Table 9-1 DAPs information for weather forecast

Register	Name	Data Item
BDS code 5,0	Track and turn report	True Track Angle
		Ground Speed
		True Airspeed
BDS code 6,0	Heading and speed report	Magnetic Heading
		Mach Number

The temperature is the function of Mach number and true airspeed. To estimate horizontal wind speed and direction, calculating zonal wind speed and meridional wind speed from ground speed, true airspeed, true track angle and true heading angle. The true heading angle is obtained from magnetic heading angle and magnetic declination which is given by a quadratic equation of aircraft position. Then the wind and temperature as observation data were used to produce the initial fields of the numerical model, resulting in the improvements of weather forecast accuracy.

The results of the experiments indicate that Mode S DAPs data have the potential to improve forecasts of rainfalls and shear-lines. For details, please refer to the IP11 presented by Japan at the Mode S DAPs/3.

9.4 Use of Barometric Pressure Setting

When the aircraft is below the transition level the pilot is required to set barometric pressure setting in altimeter to local QNH/QFE. Wrong barometric pressure setting (especially QNH higher than actual) can lead to cleared flight level deviation or more serious controlled flight into terrain, as the pilot sees higher altitude on his altimeter and the flight management system determines the lower target altitude base on barometric pressure setting and selected altitude. Every millibar of barometric pressure setting error may add 30 feet of error to altimeter and target altitude.

Constantly checking if the barometric pressure setting in DAPs is consistent with the airport's QNH can alert the controller to avoid similar situations. In Feb 2021, an aircraft was cleared to descend to 7000 feet. The pilot set the right selected altitude, but forgot to set barometric pressure setting. At that time, the airport QNH was 1013, while the crew barometric pressure setting was 1118.5. An alarm system notified the controller of this situation. The error was corrected after the controller prompted the pilot preventing a dangerous situation.

9.5 Application of geometric height of ADS-B in analysis of Height-Keeping-Performance in RVSM

TVE, AAD and ASE are important indicators reflecting the height keeping performance of aircraft, which can be calculated based on ADS-B data, the definitions of TVE, AAD, ASE and FTE in Doc 9574 are as followed:

Total vertical error (TVE). *The vertical geometric difference between the actual pressure altitude flown by an aircraft and its assigned pressure altitude (flight level).*

Assigned altitude deviation (AAD). *The difference between the transponder Mode C altitude and the assigned altitude/flight level.*

Altimetry system error (ASE). *The difference between the altitude indicated by the altimeter display, assuming a correct altimeter barometric setting, and the pressure altitude corresponding to the undisturbed ambient pressure.*

Flight technical error (FTE). *The difference between the altitude indicated by the altimeter display used to control the aircraft and the assigned altitude/flight level.*

The section 4.10 of Appendix A of Doc 9574 outlines the method for estimating ASE. The description is as followed:

An aircraft's actual ASE at any time is the difference between its actual TVE and contemporaneous actual FTE. Given a measure of TVE and a contemporaneous AAD for the aircraft, the difference between TVE and AAD provides an estimate of ASE.

Figure 9-1 shows the relationship between the vertical errors. As noted in Doc 9574, correspondence error can be negligible when estimating ASE, so RMAs only estimates TVE, AAD and AES usually.

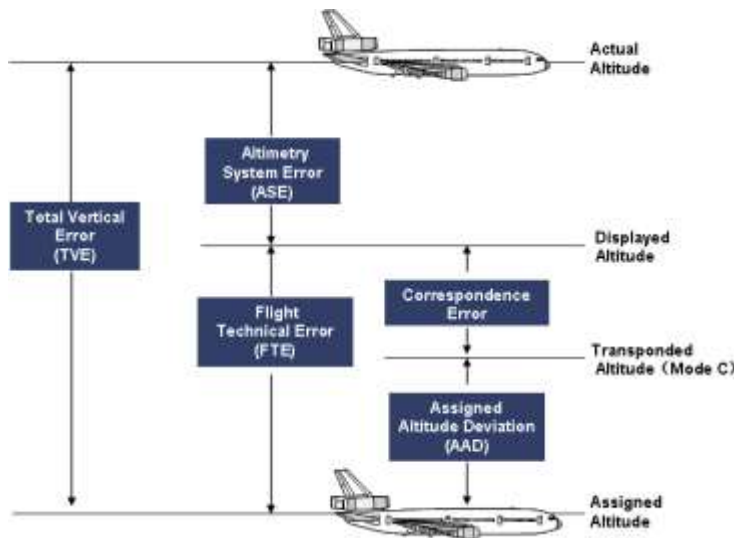


Figure 9-1: Relationship between the vertical errors

Figure 9-2 shows the calculation process of TVE, AAD and ASE based on ADS-B data. It should be known that the aircraft actual geometric altitude and Mode C pressure altitude are included in ADS-B data. For assigned pressure altitude, it can be inferred from Mode C pressure altitude. And for the corresponding geometric altitude, it can be calculated by combining the inferred assigned pressure altitude/FL and the MET data. The difference between aircraft actual geometric altitude and geometric altitude of the inferred assigned pressure altitude/FL is TVE, the difference between inferred assigned pressure altitude/FL and Mode C pressure altitude is AAD, and the difference between TVE and AAD is ASE.

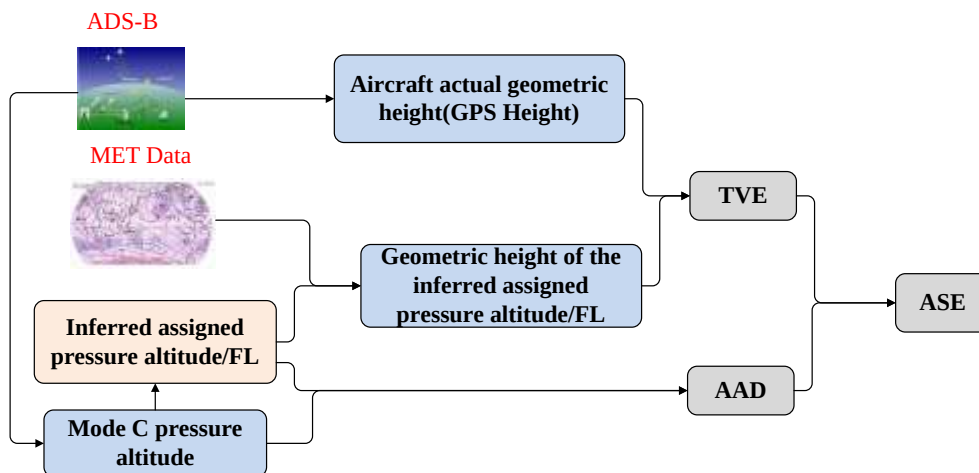


Figure 9-2: Calculation process of TVE, AAD and ASE based on ADS-B

In 9574, the error ranges of TVE, AAD and ASE are defined at the same time

- 1) $TVE \geq 90 \text{ m (300 ft)}$.
- 2) $ASE \geq 75 \text{ m (245 ft)}$; and
- 3) $AAD \geq 90 \text{ m (300 ft)}$.

9.6 Use of ADS-B DAPs for GPS interference identification

ADS-B positioning relies on GPS systems. In recent years, the number of civil aircraft affected by GPS interference has increased rapidly that affected the ADS-B positioning performance of civil aviation and the safety of civil aviation transportation.

Through the monitoring and analysis of historical data, we found that when the rate of velocity and position changes, NIC, NACp, all change simultaneously, it can be considered as ADS-B abnormal due to GNSS interference. If only one or two of these features change, the abnormal data may not be caused by GNSS interference..

According to this feature, the ADS-B DAPs data can be used for real-time monitoring of GPS interference, which can assist radio management departments to quickly locate GPS interference sources. For details, see MODE S DAPs WG/5-IP/10-“A GPS INTERFERENCE IDENTIFICATION METHOD BASED ON ADS-B DATA”.

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APPENDIX 1: Mode S DAPs Analysis

a) Data Recording Configuration

Figure 1 represents an example of a configuration for data recording. The Mode S sensor sends interrogations to an individual aircraft using a unique ICAO 24-bit aircraft address. The Mode S transponder has 255 BDS Registers. Each register stores aircraft parameters data derived from FMS or other sensors. The messages can be readout on demand by a ground interrogator, in addition to/or being broadcasted.

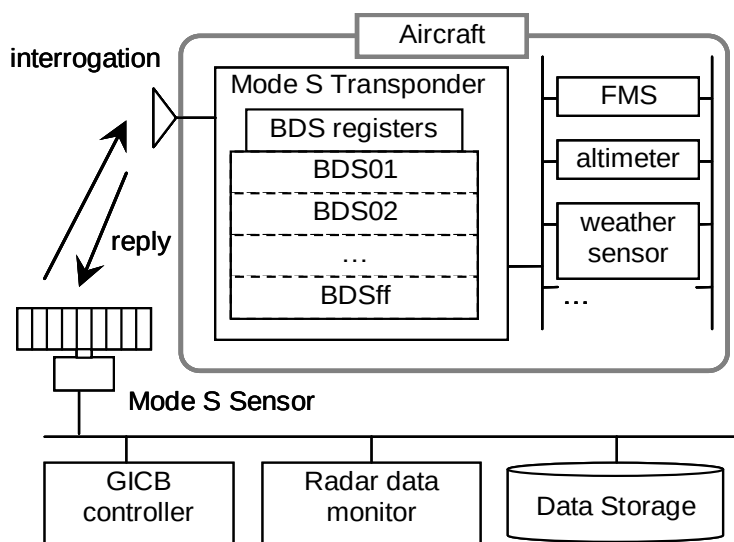


Figure1 - Example of Data Recording Configuration

b) Data Analysis

As described above section, erroneous DAPs data have been observed due to failure or improper setting/installation of Mode S avionics equipment. Bad data hinders the use of DAPs by the ATM service. To employ DAPs for ATM services, the reliability of DAPs is important. Therefore, it is necessary to analyze the recorded data to ensure reliability of the DAPs data.

If a controller finds some problem during the application of the Mode S DAPs, the ATS providers can analyze the recorded data to find the exact reason which caused the problem. If the ATS equipment has a fault which caused the problem, the ATS provider should implement a solution as soon as possible. If the ATS provider proves that the problem is caused by an avionics fault, then the problem should be reported to the appropriate party to solve the problem. The ATS providers need to devise mechanisms and procedures to address identified faults.

ATS providers should develop systems to analyze the routine recorded data. From the analyses, ATS providers can provide more information of the transponder's performance such as SI capability, datalink capability etc. The information can be used to improve the capability of the operation of Mode S DAPs equipment. By analyzing the recorded data, advice on avionics anomalies and faults, which have been detected, can be passed onto the regulators and the aircraft operators.

c) DAPs Data Validation

To ensure that Mode S DAPs are operating in conformance with the ICAO requirements, validating DAPs data is highly recommended. It has been noted that there are some drawbacks in the traditional methodology of executing tests for aircraft on the ground as follows:

- 1) Avionics for DAPs consist of several devices and functional blocks. They are interconnected, and the configuration is complicated.
- 2) Avionics and configuration differ depending on each aircraft.
- 3) It is difficult to cover the possible test patterns completely.
- 4) Ground test methodology would not detect failures or anomalies that occur after the testing.

Responding to these drawbacks, MIT Lincoln Laboratory developed and proposed a DAPs validation methodology, which monitors DAPs data received from actual flying aircraft to detect erroneous data. The MIT validation methodology is mainly categorized by two groups, static value tests and dynamic value tests.

Static value tests are executed to detect erroneous values of the bits and fields in BDS registers which do not change during a flight. Those bits and fields represent the avionics system's configuration, capability, and status information. These tests verify that those bits and fields are proper values in compliance with the ICAO regulations for DAPs applications. Table 1 shows an example of static value tests. As can be seen by the table, failed data were detected in each BDS register test. For BDS Register 20₁₆, failed data with wrong character coding were caused not due to equipment problem, but to faulty data input.

Table 1 Example of Static Value Tests

BDS Register	Test Item	Total Count		Aircraft	
		Executed	Failed	Executed	Failed
BDS code 1,0	Aircraft identification capability flag = '1'	544,980	7,183	3,615	146
BDS code 2,0	Each character conforms to ICAO 6-bit character coding	737,993	1,516	3,596	144
BDS code 4,0	Unavailable data fields are set at zero	54,248,802	1,755	3,614	4

Dynamic value tests validate the values which dynamically change according to aircraft motion, such as aircraft speed and track angle. The tests compare the DAPs values with equivalent data like radar-measured positions. If the difference between DAPs values and radar-derived parameters exceeds the acceptability threshold, the DAPs value is accounted as an error. Figure 2 represents an example of dynamic value tests. This figure indicates that ground speed differences between DAPs data and radar-derived data fall inside the threshold range.

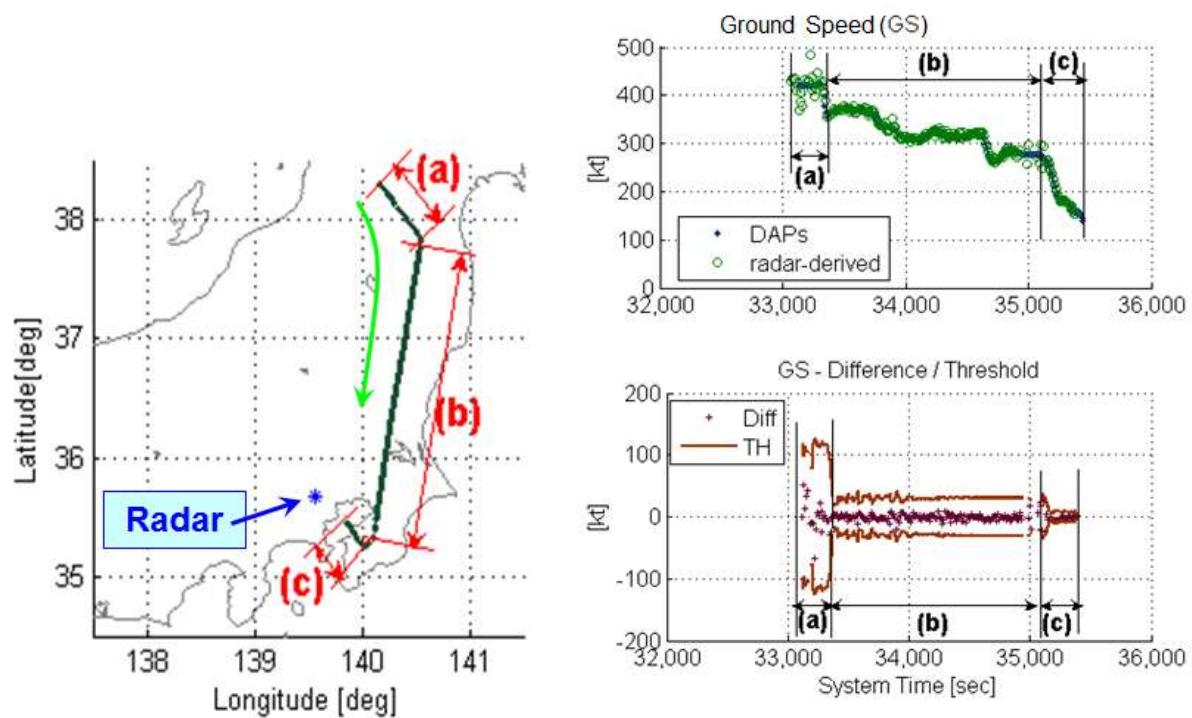


Figure 2 - Example of Dynamic Value Tests

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APPENDIX 2: LIST OF IDENTIFIED ISSUES

Ref.	Issue	Cause	Safety Implications to ATC (Yes / No)	Recommendations
1.	Wrong ground bits in DAPs led to the track decoupling from the flight plan	Through joint investigation with the airlines, it found that parts of the aircraft A were exchanged with another aircraft B for test. The malfunction part was discovered when the wrong ground bits data was found coming from the aircraft B.	Yes The wrong ground bits in DAPs could make ATM automation system display track decoupled with flight plan	
2.	Wrong aircraft identification	Many cases of wrong aircraft identification were found at the beginning of mode S operation. All related data collected and sent to the relevant airlines by the management department. Through joint investigation with the airlines, it was found that the issue is normally due to pilot's error.	Yes Wrong aircraft identification could lead to wrong flight plan coupling.	Through the joint efforts of ATMB and the airlines, the aircraft identification data became more and more accurate.
3.	Wrong Barometric Pressure	Barometric Pressure, such as BARO or QNH, is available in Mode S BDS code 4,0. Initial testing found that data above the transition level for some aircraft types would not be useful due to a mismatch between what the crew set in the cockpit, and what the aircraft Downlinked.	Yes There will display a wrong Barometric Pressure with aircraft in ATM automation system.	EASA Safety Information Bulletin SIB-2016-05R2 ("Incorrect Downlink Barometric Pressure Settings") covers this issue.
4.	Different processing between Mode A/C and Mode S Altitude	Currently, the altitude accuracy of Mode A/C radar is 100ft, while that of Mode S radar is 25ft. The altitude tracking, and display mechanism of ATM automation systems could be received both precisions altitude data.	Yes In Mode S radar and Mode, A/C radar overlapped area, the ATM automation systems might display an altitude jumping.	The altitude tracking, and display mechanism of ATM automation systems need to be optimized to avoid altitude jumping.

5.	Mode S interrogators request the aircraft transponder registers too frequently in busy airspace	If Mode S interrogators request the aircraft transponder registers too frequently in busy airspace, it may appear that the transponder registers information cannot complete the whole transmission process. The BDS parameters requesting rule needs to be set by the Mode S interrogator reasonably.	Yes ATM automation system would display track delay or intermittent interruption of radar data.	The data transmission rate of Mode S radar to feed ATM automation system needs to be selected reasonably to meet the requirements of ATC operations in busy airspace to prevent track delay or intermittent interruption of radar data.
6.	Mode S DAPs data does not correspond to the content of the requested register	It has been noted that from time to time Mode S DAPs data does not correspond to the content of the requested register. For example, the content of BDS code 5,0 is received when extracting BDS code 4,0. This phenomenon is called “BDS swap”. Table 1 represents an example data of BDS swap. The table shows the data of BDS code 0,5/4,0/5,0 data downlink from an aircraft in three sequential scans. As can be seen by the table, BDS swap occurred at 08:05:45.	Yes Wrong information could display to controller.	Different options can be implemented to decrease the impact of such as: 1. limit the number of radars extracting aircraft registers 2. implement specific filters in radar or in the surveillance data processing to discard the erroneous data (e.g. when two different registers are received with the same content they are both discarded)

7.	Duplicated aircraft address	One case was related to a local airline, wrong spare parts of the airplane were installed by mistake during maintenance. The airline replaced the spare parts after being informed. Another case was military aircraft. Another reason has been observed that in many cases the 24-bit aircraft address transmitted by the aircraft does not match its nationality (i.e. its State of Registry's block) or is otherwise incorrectly configured in the transponder. Care needs to be taken to ensure that the registration and the 24-bit address of every aircraft are processed and assigned simultaneously by the regulatory authority, and reporting mechanisms are in place to rectify incorrect configurations.	Yes The possible consequences are as follows: 1. An aircraft may be locked out in error, if it is the same beam. This may result in a new aircraft not being detected when it enters Mode S radar coverage. 2. Possible track label swap for crossing aircraft, this may result in incorrect labeling of an aircraft on the Radar screen. 3. In the technical operation of Mode S Elementary surveillance, duplicated address may result in the possible loss of a track when the two aircraft are crossing due to the interrogation scheduling within the ground station.	According to Annex 10, the aviation authority of each State is responsible for assigning 24-bit addresses to all aircraft in its registry using the block allocated by ICAO to that State. The duplicate address should be detected and reported. Without duplicate address detection, if an aircraft enters the range of the Mode S SSR with the same ICAO 24-bit address as that of an existing target, the information of the new aircraft could be erroneously associated with the existing target. Once the Mode S DAPs System detect more than one aircraft is transmitting the same ICAO 24-address, it will initiate a duplicate address report and a duplicate address condition shall be declared, and when receive new information of this address, the system should associate the information by ID or position but not the address.
8.	incorrect aircraft address in flight plan	Although the overwhelming majority aircrafts are equipped with Mode S transponders, many flight plans are not filed with the correct aircraft address in item 18.	Yes This affects the function of aircraft address correlation in ATM automation system.	

9.	incorrect wind speed and direction	Aircrew round the system output figures from Spot Wind data was the main reason for variations by crew response. e.g. Recorded wind 283/42kts, crew response 280/40kts.	No	
10.	empty ACAS RA message	ASTERIX message “I048/260, ACAS Resolution Advisory Report” indicates that airplane is in ACAS RA condition. In some cases, all zero I048/260 reports are received in the ATM automation system through Mode S radar.	Yes ATM automation system may generate false ACAS alarm from Empty RA message.	ACAS message handling feature at ATM system must be checked on at its installation stage following the ACAS message flow
11.	erroneous SFL information	It is noticed ATM automation system could receive erroneous SFL information due to the BDS swap problem and other reasons.	Yes ATM automation system may generate false SFL mismatch alarm due to the erroneous SFL information.	ATM automation system could use multiple data sources to check the SFL data.
12.	Incorrect ACAS RA information	Many cases of incorrect ACAS RA information were found at the Mode S operation. After analysis the incorrect ACAS RA data, the reason is so called “BDS Swap” and only the old type of Mode S radar has the “BDS Swap” problem.	Yes Wrong information could display to controller.	Short term solution: Reject data (BDS content and/or reply) in case of difference between UF and DF. Reject BDS content (BDS 1,0; 2,0 and 3,0) in case of first byte error. Medium /long term solution: "Overlay" function is introduced in the fifth edition of Volume IV of ICAO document annex 10. the DP (data parity) field is designed to replace the AP field to check the BDS register number in the downlink DF20 / 21. It aims to

				solve BDS swap problem from the source.
13	ADS-B Ground station generated an abnormal CPR decoding phenomenon	An abnormal CPR decoding phenomenon that caused by the airborne aircraft transmits the Surface Position state.	YES Abnormal CPR decoding may cause the aircraft target to jump or split on the ATM automation system.	The CPR decoding algorithm of the ground station should follow the standard of DO260

Table 1 Example Data of BDS Swap

BDS Register	Time of Scan		
	08:05:35	08:05:45 (BDS swap occurred)	08:05:55
BDS code 0,5	605f80c056966f	a3280030a40000	605f845303ce8d
BDS code 4,0	a3280030a40000	a3280030a40000	a3280030a40000
BDS code 5,0	fff8cf1f800489	a3280030a40000	ffb8cf1f80048a

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APPENDIX 3: A Brief Introduction of Mode S SSR DAPs Data Source

1. Introduction

1.1 During the 2nd meeting of ICAO APAC Mode S DAPs WG, China presented an information paper regarding the Mode S DAPs data source, the meeting was of the view that the content of the paper will help in the understanding of the basic mechanism of avionics relevant to surveillance application and implementation of DAPs.

-Refer to Mode S DAPs WG/2 IP05 “Preliminary Study of DAPs Data Sources”

1.2 The Mode S DAPs provides useful information on aircraft that will enhance ATM operations. More attention should be paid when introducing Mode S DAPs and it's important to clearly understand what these parameters are and where these parameters come from. This text provides give some brief information about the parameters.

2. Mode S SSR DAPs ELS and EHS

2.1 Mode S DAPs-based surveillance includes ELS (Elementary Surveillance) and EHS (Enhanced Surveillance).

2.2 Most of the ELS parameters are capability parameters of the aircraft, hence are static. They can be used for improved aircraft identification, and have less direct impact on ATC operations. The ELS parameters are shown in Table 2.1.

Table 2.1 ELS Parameters Information

	Register	DAP Set	Bits	Units	Quantity	Range
ELS		24-Bit Aircraft Address (AA)	NA	NA	NA	NA
		Transponder Capability (CA)	NA	NA	NA	NA
		Flight Status (FS)	NA	NA	NA	NA
		Altitude Reporting in 25ft	NA	ft	25	[-1000, 50175]
	BDS 1,0	Datalink Capability Report	56	NA	NA	NA
	BDS 1,7	Common GICB Capability Report	56	NA	NA	NA
	BDS 2,0	Aircraft Identification Report	56	NA	NA	NA
	BDS 3,0	ACAS Resolution Advisory Report	9-22	NA	NA	NA

2.3 EHS parameters are more related to the aircraft's intention and status, and most of them are dynamic. The implementation of EHS parameters has a larger impact on controllers. The EHS parameters are shown in Table 2.2.

Table 2.2 EHS Parameters Information

	Register	DAP Set	Bits	Units	Quantity	Range
EHS		Selected Altitude (MCP/FCU)	2-13	ft	16	[0, 65520]
	BDS 4,0	Selected Altitude (FMS)	15-26	ft	16	[0, 65520]
		Barometric Pressure Setting	28-39	mb	0.1	[0, 410]
	BDS 5,0	Roll Angle	3-11	dg	45/256	[-90, +90]

BDS 6,0	True Track Angle	14-23	dg	90/512	[-180, +180]
	Ground Speed	25-34	kt	2	[0, 2046]
	Track Angle Rate	37-45	dg/s	8/256	[-16, +16]
	True Airspeed	47-56	kt	2	[0, 2046]
	Magnetic Heading	3-12	dg	90/512	[-180, +180]
	Indicated Airspeed	14-23	kt	1	[0, 1023]
	Mach No	25-34	NA	2.048/512	[0, 4.092]
	Barometric Altitude Rate	37-45	ft/min	32	[-16384, +16352]
	Inertial Vertical Velocity	48-56	ft/min	32	[-16384, +16352]

3. Mode S SSR DAPs Data System

3.1 The ELS and EHS parameters originate from various sensors and cockpit settings. After being organized by the avionics systems, the information is being sent to the transponder through standard aircraft data buses, and subsequently formatted by the transponder and stored inside the relevant Binary Data Storages (BDS). The ground-based surveillance system could downlink desired DAPs by specific Mode S GICB (Ground Initiated Comm-B) protocol.

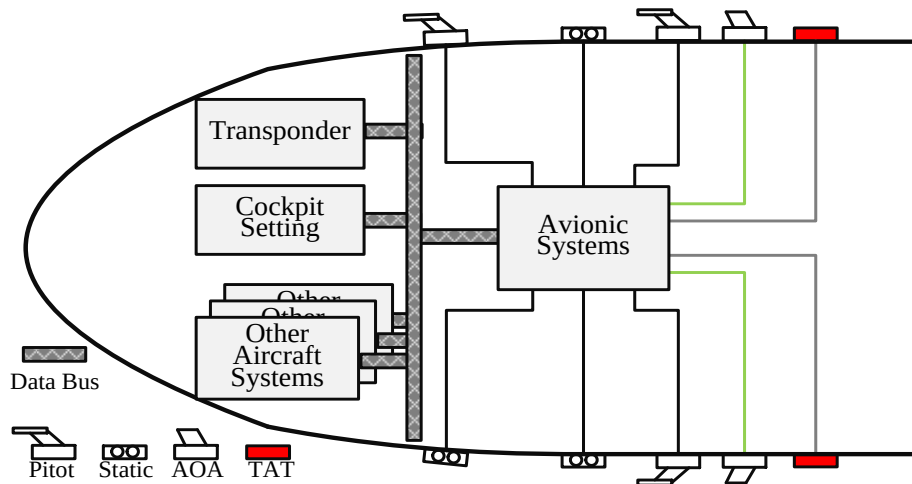


Figure 3.1 Typical DAPs Data Source Block Diagram

Transponder and TCAS Computer

3.2 The most common standard of the civil aircraft transponder, the Mark 4 Air Traffic Control Transponder, is based on the ARINC 718A standard. There are 3 main interface plugs defined on the rear panel, namely TP (Top Plug), MP (Middle Plug), and BP (Bottom Plug).

3.3 The airborne collision avoidance system, Traffic Computer TCAS and ADS-B Functionality, is based on the ARINC 735B standard. There are 6 main interface plugs defined on the rear panel, namely LTP (Left Top Plug), LMP (Left Middle Plug), LBP (Left Bottom Plug), RTP (Right Top Plug), RMP (Right Middle Plug) and RBP (Right Bottom Plug).

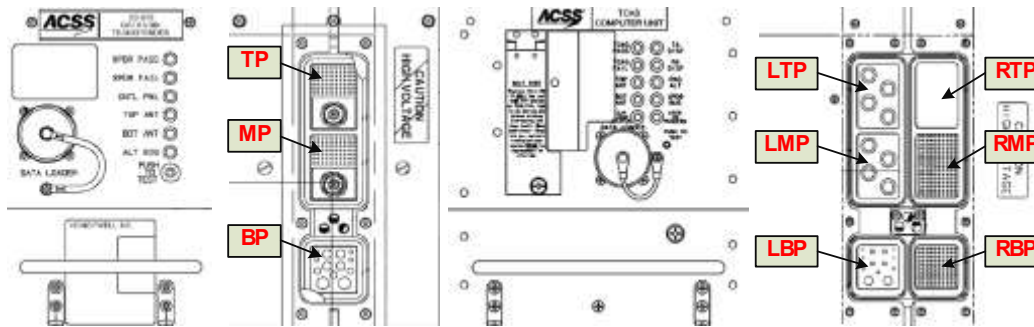


Figure 3.2 Transponder and TCAS Computer Examples from ACSS

Data Bus

3.4 The most common data bus, the Digital Information Transfer System, is based on the ARINC 429 standard. The standard defines the data transfer between most of the avionics systems. There are also other standards such as the ARINC 629 used on Boeing B777, Airbus A330 and A350, as well as the ARINC 664 (AFDX, Avionics Full Duplex Switched Ethernet) used on A380 and B787.

Avionics and DAPs Data

3.5 The Aircraft Address (AA) is a parameter programmed into the aircraft frame after the address is allocated by the State registration authority. Normally there are 2 ways to program this parameter, one is to program the pins of the MP (connected for “1”, open for “0”), and the other is to use Aircraft Personality Module (ARINC 607) to store the address, and then interface to the MP.

Note: For more detailed information about Aircraft Address, refer to ARINC 718A Attachment 2B. For APM implementation guidelines, refer to ARINC 718A Attachment 9.

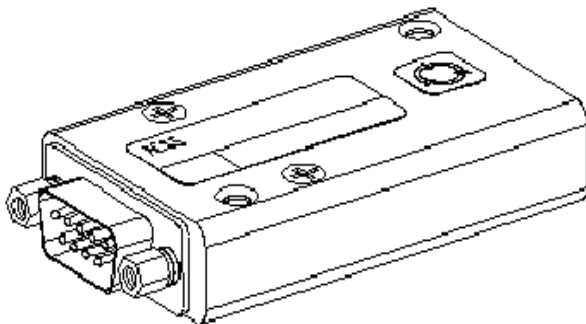


Figure 3.3 APM Example from ACSS

3.6 The Transponder Capability (CA) is a result of the combination of on-the-ground status and transponder capability level. Normally the on-the-ground status is automatically indicated by the weight sensor fitted on the aircraft, but some GA planes use manual means to indicate the status by switching the transponder knob to the GND option. The transponder receives on-the-ground status from the TP pins (5J and 5K), make validation of the status with Ground Speed, Radio Altitude or Airspeed, and then announce the status. The transponder capability level is a static value which is fixed after manufacturing.



Figure 3.4 TT31 Mode S Transponder from TRIG

3.7 The Flight Status (FS) is a result of combination of the on-the-ground status, SPI, and Alert. The on-the-ground is the same as in 3.6, the SPI is from pushing IDENT function button of the transponder by pilot, and the Alert is produced by changing Mode A code (If changed to 7500, 7600, 7700, that's permanent alert; and if changed to other codes, that's 18 seconds temporary alert).

3.8 The Common Usage GICB Capability Report is generated by the transponder itself by detecting the corresponding input data availability, and then set the corresponding bit related to that GICB register.

3.9 The main source of Aircraft Identification is from FMS, input by pilot through Flight ID (or Flight No) menu, and the related data transmitted to transponder by specific data bus (ARINC 429 Labels 233~237). If the Flight ID is empty, then the Aircraft Registration data may be provided within another data bus (ARINC 429 Labels 301-303).

3.10 According to TCAS standard (ARINC 735B Chapter 3.3.4.1), the Datalink Capability Report and the Resolution Advisories Report are sent to the Transponder from TCAS Computer by specific protocol (TGD-TCAS to Transponder data transfer protocol, and Transponder to TCAS data transfer protocol is named XGD. The data bus used is ARINC 429 Label 270). The data are sent from RMP of the TCAS Computer to TP of the Transponder, related pins refer to Figure 3.5.

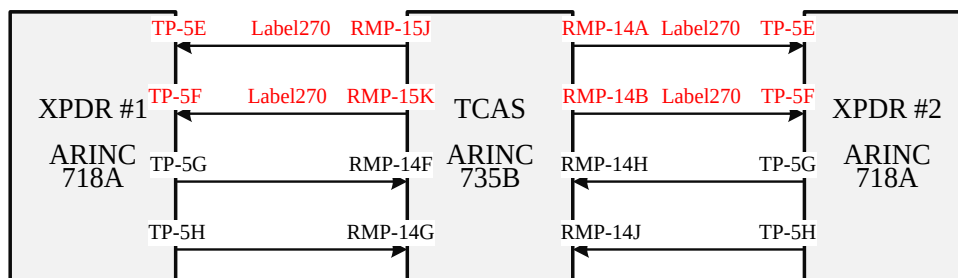


Figure 3.5 Illustrations of Datalink Capability and RA Report Transfer

3.11 There are 2 kinds of Selected Altitude, one is from MCP/FCU (Boeing's Mode Control Panel and Airbus's Flight Control Unit), and the other is from FMS (Flight Management System). The first one is set by the pilot in response to a controller's instruction during the flight, the second one is calculated by the FMS automatically to achieve the best cost-efficient.



Figure 3.6 MCP of Boeing B787 & FCU of Airbus A380

3.12 The Barometric Pressure Setting (BPS) is also located in the MCP/FCU, and set by the pilot rotating the knob to the pressure value comes from the aerodrome's ATIS (Automatic Terminal Information System).

3.13 The other parameters mainly come from the sensors onboard the aircraft, the sensors are organized in 3 groups, the air data sensors, the inertial sensors and the magnetic sensor.

3.14 The air data sensors are used to sense the medium through which the aircraft is flying, including pitot (static) probe, static port, temperature sensor, angle of attack sensor. Typical sensed parameters are total pressure (Pt), static pressure (Ps), pressure changing rate, air temperature (TAT), and angle of attack. Derived data includes Barometric Altitude (ALT), Indicated Airspeed (IAS), Vertical Speed (VS), Mach (M), Static Air Temperature (SAT), Total Air Temperature (TAT), True Airspeed (TAS) and Angle of Attack (AOA). The simplest system provides ALT and IAS.



Figure 3.7 Air Data Sensors and Integrated Sensor on Airbus A380

3.15 The inertial sensors are used to detect the motion of the aircraft in a universal reference system, including position gyroscopes, rate gyroscopes and accelerometers. By detection of the 3D dynamic of the aircraft, derived data includes Ground Speed (GS), Wind Speed, Wind Direction, True Track Angle, Roll Angle, and Track Angle Rate and so on.

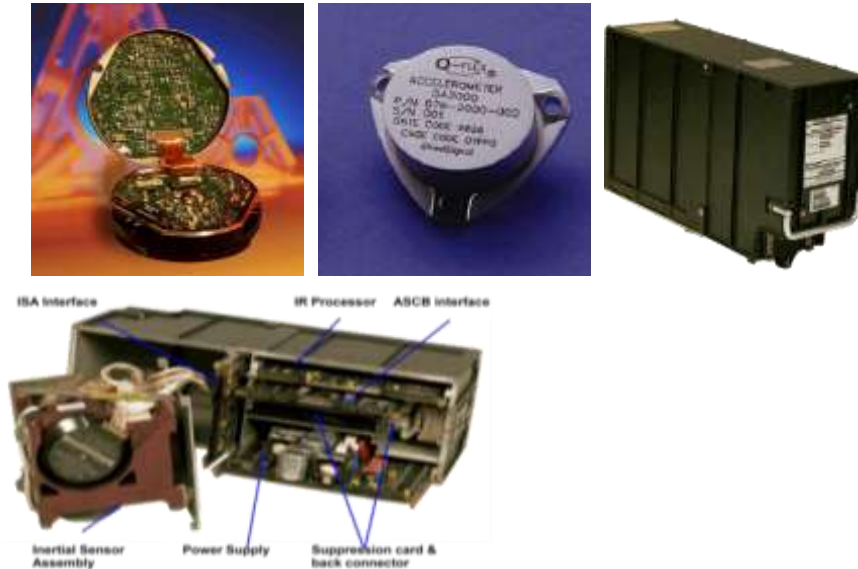


Figure 3.8 Gyro, Accelerometer and LASEREF IV IRU from Honeywell

3.16 The magnetic sensor is used to sense the direction and to find the magnetic north, and give out the main parameter of Magnetic Heading. The world magnetic model is show below:

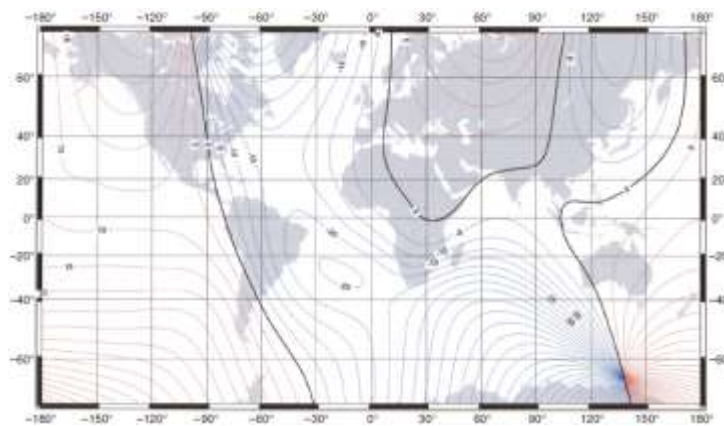


Figure 3.9 World Magnetic Model 2000

3.17 Some airplane platform uses an integrated solution to process these data, each air data sensor is connected with an Air Data Module (ADM) which converts the analog data to digital data and make the compensation of the instrumental and positional error. These data then feed to the input of Air Data Inertial Reference Systems (ADIRS) to calculate all the parameters mentioned before. And after that the parameters are sent to transponder and other avionics systems by the Data Bus.

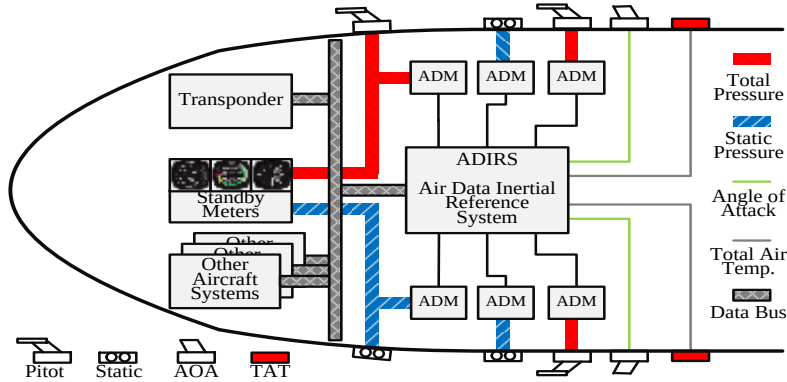


Figure 3.10 Typical ADIRS Architecture

3.18 The most commonly used data bus for parameters from ADIRS is ARINC 429 (and the newest evolution is AFDX invented by Airbus and implemented in various new aircrafts like A380 and B787), and the standard ARINC 429 Labels used by these parameters are as follows:

Table 3.1 ADIRS Parameters Used Labels of ARINC 429

No	DAP Item	Label
1	Mach No.	205
2	Indicated Air Speed	206
3	True Air Speed	210
4	Barometric Altitude Rate	212
5	Ground Speed	312
6	True Track Angle	313
7	Magnetic Heading	320
8	Roll Angle	325
9	Track Angle Rate	335*
10	Inertial Vertical Velocity	365

**Note: This label in GAMA configuration is not used for Track Angle Rate*

3.19 By using these parameters, the aircraft dynamic is illustrated as in Figure 3.11.

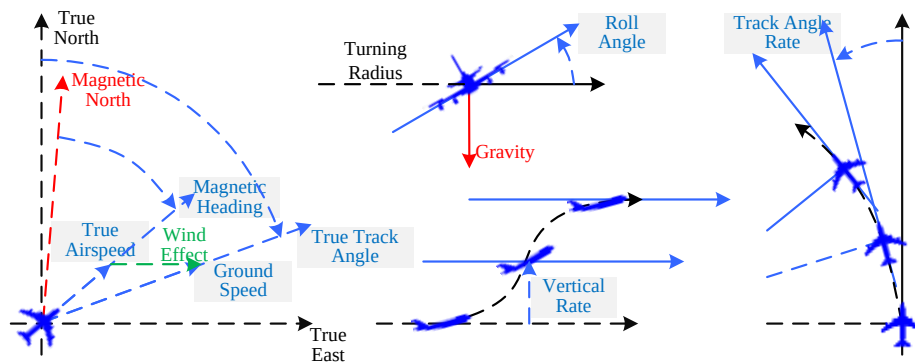


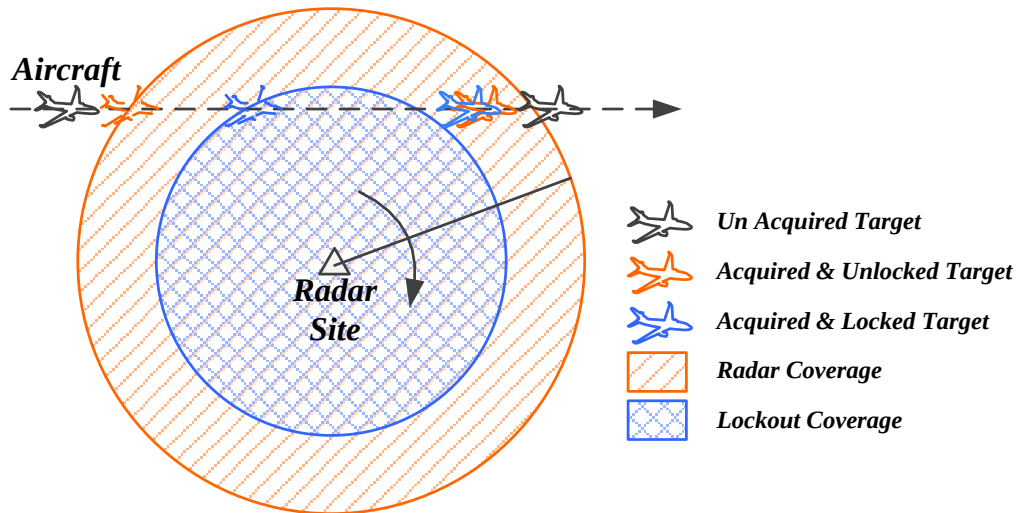
Figure 3.11 Illustration of Aircraft Dynamic

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APPENDIX 4: Mode S Parameter Set

Radar Coverage R

1.1 The Mode S radar coverage is defined as the farthest target the radar will process. If the Mode S radar uses a lockout map, the difference of the two coverage ranges should be noticed.



1.2 The radar coverage will decide the minimal All-Call period, this is to say, the time of All-Call period should:

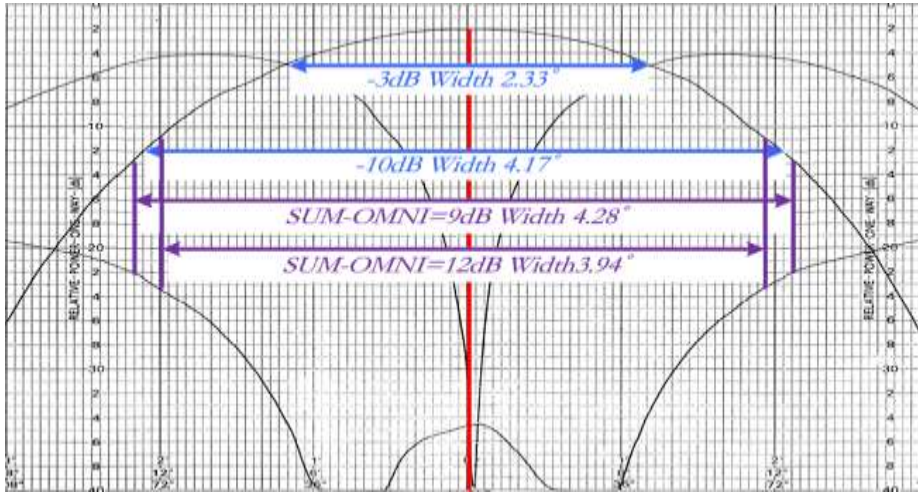
$$T \geq \frac{R * 2 * 1852}{3 * 10^8}$$

Antenna Period T_a

2.1 The antenna period is the time of a successful antenna rotation, this time actually has very important influence of the total time resource of the radar. Lower antenna rotation speed will provide rich antenna period, hence time resource of the radar. The most commonly used antenna period is 4000ms (15rpm) and 6000ms (10rpm) for terminal surveillance radar.

Antenna Beamwidth B

3.1 Most of the secondary surveillance radar uses the same LVA antenna, the beam is more or less the same, and the standard interrogation beam has a -3dB width of $2.45^\circ \pm 0.25^\circ$. In Mode S interrogation, the suppression requirement actually allow to use a wider beam width than -3dB width, most of the radar choose 3.8° or roughly the -10dB beam width.



Time on Target T_t

4.1 The time on target is the total time amount the radar beam covers the target during one scan, it defines the time resource upper limit for one dedicated target, it is determined by both the antenna period and the beamwidth, and the relation is as follows:

$$T_t = \frac{T_a}{360} * B$$

4.2 It should be noticed that during a mix air operation (Conventional targets and Mode S targets flying in the same area in the same time), there is a need for the Necessary Transaction. That is during an antenna scan, there should be at least 4 transactions between the radar and the conventional target, in order not to miss conventional target.

All-Call Period T_{ac} and Roll-Call Period T_{rc}

5.1 The All-Call period and Roll-Call period setting are different radar by radar, but there should be some principles:

- 1) All-Call period should long enough to allow the coverage requirement.
- 2) During the time on target, the Necessary Transaction should be guaranteed.
- 3) Time resource should allocate to Roll-Call as much as possible; and
- 4) Algorithm should be used to optimize the scheduling in the Roll-Call period.

Mode Interlace Pattern MIP

6.1 Mode Interlace Pattern defines the radar operating mode setting. The setting is related to the specific radar environment, hence there is no standard MIP.

6.2 All the modes Mode S radar can use is listed in the following table:

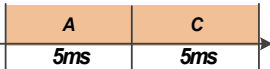
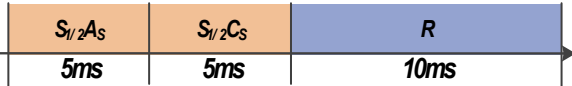
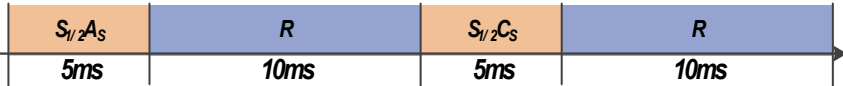
No.	Mode	Description	Pulse Used
1	A	Mode A interrogation	8μs between P1 and P3
2	C	Mode C interrogation	21μs between P1 and P3
3	A _S	Mode A Only All-Call	8μs between P1 and P3, and short P4
4	C _S	Mode C Only All-Call	21μs between P1 and P3, and short P4
5	S _L	Mode ACS All-Call	8μs, 21μs between P1 and P3, and Long P4
6	S _{PO}	Mode S Only All-Call P for PR, O for LO	2μs between P1 and P2, and P6 UF11 inside P6
7	R	Mode S Roll-Call	2μs between P1 and P2, and P6 UF0/4/5/16/20/21 inside P6

6.3 For a specific MIP, the describe phraseology defines as follows, and also one example is listed below:

Mode[Time]/ Mode[Time]/ Mode[Time]/.....

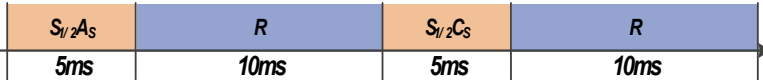
Note: The All-Call and Roll-Call periods are separated by “/”, the “Mode” is one of the Modes listed above, and the “[Time]” stands for the duration of the periods.

6.4 An example is show as follows:

No.	Mode	MIP
1	Conventional	A[5.0]/C[5.0]  Mode A and Mode C repeat, both durations are 5ms
2	Mode S #1	S_{1/2}A_S[5.0]/S_{1/2}C_S[5.0]/R[10.0]  2All-Call periods and 1 Roll-Call period repeat, All-Call duration is 5ms, Roll-Call duration is 10ms In the first All-Call, the PR=1/2, and use Mode A with short P4 In the second All-Call, the PR=1/2, and use Mode C with short P4
3	Mode S #2	S_{1/2}A_S[5.0]/R[10.0]/S_{1/2}C_S[5.0]/R[10.0]  1All-Call,1Roll-Call,1All-Call,1Roll-Call repeat, All-Call duration is 5ms, Roll-Call duration is 10ms In the first All-Call, the PR=1/2, and use Mode A with short P4 In the second All-Call, the PR=1/2, and use Mode C with short P4

*Interrogation Repetition Frequency **IRF***

7.1 The Mode S introduced the Roll-Call period, which makes the interrogation repetition frequency a little bit different from the Conventional Mode. There is a need to define the interrogation repetition frequency by Mode IRF_{Mode}. Normally use IRF stands for the IRF_{AC} of Conventional mode and IRF_S of the Mode S All-Call. One example is listed below:

No.	MIP	IRF
1	A[5.0]/C[5.0] 	IRF_A=100Hz IRF_C=100Hz IRF_{AC}=200Hz
2	S_{1/2}A_s[5.0]/R[10.0]/S_{1/2}C_s[5.0]/R[10.0] 	IRF_A=33.3Hz IRF_C=33.3Hz IRF_{AC}=66.7Hz IRF_S=66.7Hz IRF_R=66.7Hz

DAPs Extraction Strategy

8.1 The DAPs extraction strategy normally includes the BDS number, extraction priority, extraction period, and re-extraction.

1) BDS number stands for the setting of the number of BDSs which radar is going to extract. It doesn't include the ELS registers, these registers should not be extracted periodically.

2) Extraction priority stands for the priority of each BDS when the radar is performing extraction, the priority should be in accordance to the user's needs;

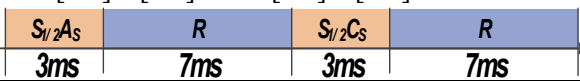
3) Extraction period stands for the period of the dedicated BDS extraction, normally described by the antenna scan number.

4) Re-extraction stands for the function of re-extraction of the dedicated BDS in the same beam dwell when the extraction is failed, but it's not recommended to use re-extraction more than 2 times.

Mode S Parameter Set Example

9.1 The following is an example of the Mode S Parameter Set:

No.	Parameter	Unit	Value	Note
1	R Coverage Range	NM	200	Equivalent All-Call Time $\frac{200 * 2 * 1852}{3 * 10^8} * 10^3 \approx 2.47ms$
2	Ta Antenna Period	ms	3800	Antenna Rotation Period
3	B Work Beamwidth	°	3.8	Mode S Work Beamwidth Normally Greater Than - 3dB width of 2.45°
4	Tt Time on Target	ms	40.1	The Time on Target In One Scan $\frac{3.8}{360} * 3800 \approx 40.1ms$
5	Tac	ms	3.0	Equivalent Coverage Range

	All-Call Period			$\frac{3 * 10^8 * 3.0 * 10^{-3}}{1852 * 2} \approx 243\text{NM}$
6	Trc Roll-Call Period	ms	7.0	This Period Related To The Extraction Efficiency
7	MIP	——	——	$S_{1/2}A_s[3.0]/R[7.0]/S_{1/2}C_s[3.0]/R[7.0]$ 
8	IRF _{AC}	Hz	100	Interrogation Repetition Frequency of Mode S All-Call
9	DAPs Extraction	——	——	No. of BDS: 3 (BDS 4,0 5,0 6,0) Extra. Priority: BDS 4,0 6,0 5,0 Extra. Period: 1 Scan Re-Extraction: Yes

APPENDIX 5: Radio Frequency (RF) Measurements and Analysis

The following is excerpted from ICAO Doc 9924 Aeronautical Surveillance Manual (Third Edition 2020), Appendix M: Interference Considerations.

1. Overview

1.1 The 1030 and 1090 MHz frequency bands form the worldwide RF network, which enables the cooperative surveillance of mobile vehicles involved in ATM including airborne vehicles (aircraft) and ground vehicles (e.g., specific vehicles operating on airport surface in critical areas). It is utilized to support civil and military (IFF) air-ground surveillance applications, air-air surveillance applications and collision avoidance applications.

1.2 In general, the 1030/1090 MHz network is robust in its ability to support the systems that utilize it but as more systems are added, performance of one or more of these systems may degrade to unacceptable levels. Since many systems are safety critical in nature, protecting the 1030/1090 MHz spectrum from reaching unacceptable utilization is paramount.

1.3 Capacity of the system is impacted by the number and types of users. Aircraft density and the number and type of interrogators directly influence the activity on these links. Information extraction from ground and aircraft to aircraft interrogators increases the activity of these RF links. High density airspace is a particular challenge as these locations tend to contain accompanying higher density of ground interrogators. The systems that utilize the 1030/1090 MHz bands have standards that limit their impact to protect the performance of all users and provide robust capacity to the system. However, available capacity can be limited in the highest density areas of the world.

1.4 Therefore, it is necessary to monitor the usage of the 1030/1090 RF network, as is required for any telecommunication network, in order to regulate its use. Such monitoring should support the determination of the remaining margin of the network. It should help identify the sources of the utilization and whether the limits are being reached by misuse of some systems operating in a non-conforming or inefficient manner to the detriment of the good operation of the other systems using the same network.

2. Radio frequency (RF) measurements

2.1 Measurements need to provide information to answer the following questions:

- a) what is the probability that a transponder correctly receives and decodes an interrogation sent on 1030 MHz (the utilization of the 1030 MHz frequency);
- b) what is the probability that a transponder is available to receive and decode interrogations and is able to reply (the availability of the transponder); and
- c) what is the probability that a 1090 MHz message is correctly received by a 1090 MHz receiver, which is impacted by overlaps of messages on 1090 MHz (the utilization of the 1090 MHz frequency).

2.2 Measurement methodologies

2.2.1 Data produced by RF measurement activities is recommended to include a minimum set of information that can adequately characterize the RF environment of the geographical area under assessment and support comparison to other measurements. Additionally, the data is intended to support comparison to other data collection measurements in other geographical areas which can provide insight to areas with high or unusual activity and help identify areas that warrant further investigation. To allow comparison between different measurements performed in different locations around the world, it is very important to define the types and the conditions of measurements. Measurements can be made from the ground and/or from the air. Each of them provides critical insight into the 1030/1090 MHz utilization.

2.2.2 Airborne measurements provide a larger area of measurement but are more difficult to conduct and result in higher cost. The airborne measurements provide both the ability to characterize ground sensor operations (1030 MHz) and transponder occupancy. Providing a 1030 MHz measurement enables the detection of all types of interrogations to which a transponder is receiving, i.e., interrogations to which a transponder does or does not transmit a reply. Therefore, it allows an estimation of transponder occupancy at the given points of measurement. It also allows the tracking of interrogations received but not generating replies (e.g., SLS interrogations, interrogations directed to other aircraft).

2.2.3 Ground measurements are more easily accomplished, less expensive but geographically limited. They allow the verification of transponder transmissions on 1090 MHz but are limited in their ability of providing a complete understanding of the environment that airborne aircraft are experiencing. Estimates of 1030 MHz activity can be somewhat estimated from measurement of 1090 MHz replies. However, there is no way to completely account for interrogations that do not result in a reply that impact transponder occupancy.

2.3 Metrics and measurement methods

2.3.1 Frequency occupancy

2.3.1.1 Method 1, In order to allow simple comparison of signal activity received on either 1030 MHz or 1090 MHz frequency, one method is to calculate a simple time occupancy that corresponds to the amount of time that there is a signal present above a given threshold without trying to extract or even decode the content of the messages. The process can be based on the following criteria:

- 1090 MHz frequency occupancy is defined by the proportion of time that there is a signal above the MTL (-84 dBm) for pulses greater than 0.3 microseconds in duration; and
- 1030 MHz frequency occupancy is defined by the proportion of time that there is a signal above the MTL (-74 dBm) for pulses greater than 0.3 microseconds in duration.

2.3.1.2 Method 2, which analyses the signal received on 1090 MHz, would be determined by decoding of, and counting the number of signals for, different types of messages. The 1090 MHz frequency

band occupancy can also be estimated using a predefined occupancy time for each type of message. This message occupancy time is defined as the time there is a signal transmitted on the frequency, i.e., a pulse is transmitted. It signifies how long the transmission is occupying the frequency and therefore possibly interfering with another signal. The table below provides the values to be used to estimate the effective occupancy time and allow comparison between different measurements/estimations made by different authorities.

<i>Type of message</i>	<i>Time occupancy in μs</i>
Mode A/C reply	4.05 (9*0.45)
Short Mode S reply or squitter	30 (60*0.5)
Long Mode S reply or Extended Squitter	58 (116 *0.5)

2.3.1.3 Note that the occupancy of a Mode A/C reply depends on the number of pulses transmitted in each reply. For this calculation, an average value of 9 pulses (2 framing + 7 code pulses) has been used. This is sufficient to provide a first order estimation for comparison with the occupancy of other signal types.

2.3.1.4 The calculation of the number of replies of a given type multiplied by their corresponding time occupancy enables characterizing the impact of different message types on the frequency. Since this uses a fixed defined time occupancy for each type of message, the occupancy determined using this method, in general, will be lower than the occupancy computed using method 1 above, since it can be expected that interfering pulses that may occur during a detected message are not accounted for using method 2.

2.3.1.5 Method 3 is similar to the previous methods. An alternate occupancy calculation is based on the number of signals received on 1030 and 1090 MHz, which are decoded and from which signal rates are determined. However, the occupancy considers the entire signal length from the leading edge of the first pulse until the trailing edge of the last pulse as the time duration regardless of whether and how many intermediate pulses are transmitted. The rationale behind this method is that in RF high-density areas, multiple signal garbling is likely to occur and therefore pulse gaps are unpredictably filled. The determination of the band occupancy is based on the signal durations, as shown in table below.

<i>Type of message</i>	<i>1030 MHz signal duration</i>	<i>1090 MHz signal duration</i>
Mode 1	3.8 μs	20.75 μs
Mode 2	5.8 μs	20.75 μs
Mode 3/A	8.8 μs	20.75 μs
Mode C	21.8 μs	20.75 μs
Mode C (Whisper/Shout)	23.8 μs	20.75 μs
Mode A only All Call	10.8 μs	20.75 μs
Mode C only All-Call	23.8 μs	20.75 μs

Mode A/Mode S All-Call	11.6 μ s	20.75 μ s or 64 μ s
Mode C/Mode S All-Call	24.6 μ s	20.75 μ s or 64 μ s
Mode C only All-Call (W/S)	25.8 μ s	20.75 μ s
Mode A only All-Call (W/S)	12.8 μ s	20.75 μ s
Short Mode S	19.75 μ s	64 μ s
Long Mode S	33.75 μ s	120 μ s

2.3.2 Determination of transponder reply and broadcast activity

2.3.2.1 By analyzing the transmissions made by a transponder, it is possible to verify if a transponder is transmitting above the minimum capabilities specified in Annex 10, Volume IV. The number of messages can be counted over 1 second and 100 msec sliding windows. The peak rates (i.e., the interval with the highest number of messages) detected over a given interval (e.g. 1 minute) can be compared to the values defined in Annex 10, Volume IV. Such information provides a good overall estimate of transponder activity caused by interrogators and makes possible the detection and further analysis of unexpected activity on the channel.

2.3.2.2 One method to estimate the number of messages transmitted by individual aircraft is by counting the number of messages received by a 1090 MHz receiver for aircraft in the vicinity of the receiver with a good link budget. However, achieving sufficient decoding performance is difficult but this method lends itself to a long-term ground-based monitoring system.

2.3.2.3 Another method is to conduct flight tests and detect and record the transmissions made by the operational transponder installed on the test aircraft. This is a good way to determine with high confidence the activity of an individual transponder in the environment. Decoding ownship replies is more accurate than attempting to analyse all the replies transmitted by all the other aircraft because the transmissions are received at high power, thereby reducing the problem of degarbling with other transmissions.

3. Additional data

3.1 Considering additional data such as aircraft environment and traffic density is desirable to assist in understanding the RF measurements that are obtained by the various methods previously identified. RF activity is a function of the number of systems operating, which includes the number and types of interrogators operating on the 1030 MHz frequency as well as the number and equipage of aircraft operating in the geographical area surrounding the measurement location.

3.2 Data to describe the aircraft environment during a measurement activity is helpful to understand the relationship between the RF measurements and the aircraft traffic in the surrounding area. Traffic density and traffic patterns influence the RF activity in any given area or region. Determining the aircraft environment may require collecting and recording data from one or more ground SSRs. Data in time intervals of 10 to 15 minutes is suggested. To some extent, aircraft information can be determined by the

RF measurement system itself. Mode S equipped aircraft can be detected by 1090 MHz reply data via the 24-bit aircraft address and additionally the position of many aircraft can be determined by extended squitter data. ACAS equipage can be determined from 1030 MHz TCAS broadcast data, extended squitter as well as DF 0/16 reply content. These methods are limited to the receiver range of the measurement system but enable determining the nearby aircraft environment.

3.3 Information to describe the ground interrogator environment during a measurement activity is helpful to understand the relationship between the RF measurements and the number of interrogators in the surrounding area. Ground interrogators vary in characteristics that influence the impact to the RF environment. The expected RF contribution from ground interrogators can be predicted based on their characteristics such as PRF, scan rate, mode interlace pattern, beamwidth, power, etc. Although there is no way to associate measured 1030 MHz Mode A/C or Whisper-Shout interrogations to a given ground interrogator without detailed analysis of interrogation timing, particularly in the mainbeam, Mode S interrogator All-Call activity can be associated via the II/SI codes. There are many factors that influence overall RF activity with Mode S since ground interrogators may be extracting many GICB registers that increase the contribution of Mode S FRUIT caused by ground interrogators. It is possible to associate All-Call interrogations with UF 4, 5, 20 and 21 interrogations by examining mainbeam activity of detected Mode S ground interrogators.

3.4 Additional data that can be helpful in assessing the RF activity in a given region is the use of interrogation and reply data that is broadcast on extended squitter by so equipped aircraft. The capability to broadcast interrogation and reply data is incorporated into the future version of 1090 MHz extended squitter as a means of collecting useful 1030 and 1090 MHz activity data. The interrogation data is useful in conjunction with flight test measurements as it provides insight to the interrogation activity at different locations in addition to own aircraft. The reply data counts from the broadcasting aircraft enable comparison to the own aircraft rates as a function of time. For the purpose of ground monitoring of RF activity over time, decoding of the interrogation and reply monitoring extended squitter messages can be used for long term assessment of RF activity and enable capture of unusual or excessive RF activity events.

**TERMS OF REFERENCE OF
SURVEILLANCE IMPLEMENTATION COORDINATION GROUP (SURICG)**

Consists of objectives and deliverables as follows:

The Objectives of the SURICG are to:

- 1) *Ensure continuous and coherent development of the Surveillance parts of the Asia/Pacific Regional Air Navigation Plan (APAC e-ANP) in a manner that is harmonized with adjacent regions, consistent with ICAO SARPs, the Global Air Navigation Plan and the Global Aviation Safety Plan;*
- 2) *Facilitate the implementation of Surveillance systems and services identified in the Aviation System Block Upgrades (ASBU) modules, APAC ANP, and Asia/Pacific Seamless ATM Plan elements using the project management principles where appropriate; and*
- 3) *Review, identify and address major issues in technical, operational, safety and regulatory aspects to facilitate the implementation or provision of efficient Surveillance services in the Asia and Pacific Regions.*

Deliverables to meet the Objectives:

- 1) *Progress report to be submitted to CNS SG addressing the SURICG deliverables (listed in 2 to 13 below);*
- 2) *Surveillance parts of the APAC ANP to be reviewed and aligned with work programme of States and, as necessary, amendment proposals prepared to update the APAC ANP to reflect changes in the operational and global requirements;*
- 3) *To review the outcome of the Surveillance Panel, SAS Panel, AN-Conf, APANPIRG and CNS SG related to surveillance, revise and update a tasks list and action items for the SURICG and formulate relevant Working Groups to work on those tasks / action items;*
- 4) *To develop regional targets/metrics for planning, implementation, measurement and monitoring of Surveillance systems and services;*
- 5) *To review and update the Surveillance Strategy by considering currently available and emerging technologies with respect to concept of operations, relative costing, technical and operational performance and maturity of alternative technology/solutions such as primary radar, secondary radar including Mode-S, ADS-B, Multilateration, ADS-C, multi-static primary radar (MPSR) and existing and emerging technology for detection of UAS including RPAS;*
- 6) *To study and identify applicable multilateration applications in the Asia and Pacific Regions considering:*
 - *Concept of use/operation*
 - *Required site and network architecture*
 - *Expected surveillance coverage*
 - *Cost Benefits Analysis*
 - *Recommended separation minimums*

- 7) To study and identify applicable Mode S ~~radar~~ and DAPs applications in the Asia and Pacific Regions considering:
- Concept of use/operation;
 - Assignment of and migration to SI code in APAC;
 - Required site and network architecture;
 - Expected surveillance coverage;
 - Cost of system;
 - Requirement of surveillance systems (focusing on radar)
 - Matching functionality required in ATC ATM automation system;
 - ~~the use of Enhanced MODE S data (DAPS)~~
 - Other currently available or emerging technologies;
 - ~~ICAO GANP and ASBU; and~~
 - Evaluation method for Mode S and DAPs performance.
- 8) To develop an implementation plan for ADS-B applications in the Asia and Pacific Regions including implementation target dates taking into account:
- available equipment standards;
 - readiness of airspace users and ATS providers;
 - identifying sub-regional areas (FIRs) where there is a positive cost/benefit for implementation of ADS-B and associated VHF voice communications;
 - developing a standardised and systematic task-list approach to ADS-B implementation; and
 - major traffic flows.
- 9) To coordinate ADS-B implementation plan and concept of operations with other ICAO regions where ADS-B implementation is going on and with relevant external bodies such as EUROCONTROL, EUROCAE, RTCA and Industry;
- 10) To encourage research and development, trials and demonstrations in the field of Surveillance and other relevant areas; 5
- 11) Facilitate implementation of surveillance data sharing (including DCPC) and sharing surveillance information and expertise between States through organizing educational seminars and providing guidance materials to educate States and airspace users
- 12) To support the ICAO in making specific recommendations, developing guidance materials, aimed at improving the Surveillance services by the use of existing and/or new procedures, facilities and technologies; and
- 13) Draft Conclusions and Decisions to be formulated relating to matters in the field of Surveillance that come within the scope of the APANPIRG or CNS Sub-group work plan.

[Note: The Implementation Coordination Group, while undertaking the tasks, should take into account of the work being undertaken by SAS, Surveillance Panels with a view to avoid any duplication.

The Implementation Coordination Group will report to CNS Sub-group and CNS Sub-group will coordinate with ATM Sub-group.]

Membership:

All APAC member States/Administrations providing air navigation services in the Asia and Pacific Regions.

The Surveillance Implementation Coordination Group shall normally invite representatives of International Organizations recognized by the ICAO Council and Industry partners as required by the group which represent important civil aviation interests to participate in its work in a consultative capacity.

INTERNATIONAL CIVIL AVIATION ORGANIZATION



ASIA/PACIFIC SEAMLESS ANS PLAN

Version 3.01, November 2019

This Plan was originally developed by the Asia/Pacific Seamless ATM Planning Group (APSAPG) and amended when appropriate by APANPIRG.

Approved by **APANPIRG/30** and published by the
ICAO Asia and Pacific Office, Bangkok

CONTENTS

SCOPE OF THE PLAN.....	1
PLAN OBJECTIVES AND DEVELOPMENT	4
EXECUTIVE SUMMARY	7
ABBREVIATIONS AND ACRONYMS	12
BACKGROUND INFORMATION	16
CURRENT SITUATION.....	30
RESEARCH AND FUTURE DEVELOPMENT POSSIBILITIES	57
MILESTONES, TIMELINES, PRIORITIES AND ACTIONS	60
~~Appendix A: Kansai Statement~~	63
~~Appendix B: Relevant 12th Air Navigation Conference Recommendations~~	64
Appendix A: Beijing Declaration	69
~~Appendix C B: Seamless ANS Principles~~	70
~~Appendix D: Capacity Expectations~~	73
Appendix ~~E~~ C: List of References	76

SCOPE OF THE PLAN

Plan Structure

1.1 The Seamless Air Navigation Service (ANS) Plan (hereinafter referred to as the ‘Plan’) references different levels of ANS planning. At the upper level is a global perspective, which is guided mainly by references to the *Global Air Navigation Plan* (GANP, Doc 9750) and its global technical planning frameworks¹, the *Global ATM Operational Concept* (Doc 9854) and the *Global Aviation Safety Plan* (GASP). Beneath this level is regional planning primarily provided by the *Asia/Pacific Regional Air Navigation Plan*, this Plan and other guidance material, in order to define goals and means of meeting State planning objectives, such as:

- Asia/Pacific Regional Air Navigation Plan requirements and objectives;
- the Seamless ANS performance framework, with a focus on technological and human performance within the GANP’s Aviation System Block Upgrade (ASBU) Block 0, Block 1 and Block 2 elements, non-ASBU elements, and civil-military cooperation elements;
- a deployment plan with specific operational improvements, transition arrangements, expected timelines and implementation examples; and
- an overview of financial outcomes and objectives, cross-industry business and performance/risk management planning.

1.2 ~~The Plan incorporated the Asia/Pacific Air Traffic Flow Management (ATFM) Concept of Operations and the Asia/Pacific Air Navigation Concept of Operations (both hereinafter referred to as ‘CONOPS’), and the Asia/Pacific PBN Plan, superseding these documents.~~

1.3 ~~Key components of this The RANP Plan, as updated, are is expected to be migrated into the Regional Air Navigation Plan Volume III under a future project to be initiated by ICAO. incorporate key components of this Plan and information on the mechanisms that enable these objectives to be met. High level support may be necessary from regional bodies that can effectively support the Plan’s implementation, such as the:~~

- ~~• Association of Southeast Asian Nations (ASEAN);~~
- ~~• Asia Pacific Economic Cooperation (APEC); and~~
- ~~• South Asian Association for Regional Cooperation (SAARC).~~

1.4 The Plan does not use ‘continental’, ‘remote’ and ‘oceanic’ areas to refer to an assumed geographical application area, as many Asia/Pacific States have islands or archipelagos that can support a higher density of Communications, Navigation, Surveillance (CNS) systems than in a purely ‘oceanic’ environment. In accordance with the CONOPS that air navigation services should be provided commensurate with the capability of the CNS equipment, it is important to categorise airspace in this manner, and simplify the numerous references to this capability throughout the Plan. Thus the Plan categorises airspace by reference to its CNS (Communications, Navigation and Surveillance) capability as:

- a) Category R: remote en-route airspace with Air Traffic Services (ATS) HF or CPDLC communications and outside the coverage of ground-based surveillance coverage; or
- b) Category S: serviced (or potentially serviced) en-route airspace – by direct (not

¹ Basic Building Blocks (BBBs) and Aviation System Block Upgrades (ASBUs)
<https://www4.icao.int/ganportal/>

dependent on a Communication Service Provider (CSP) ATS communications and surveillance; or

- c) Category T: terminal operations serviced by direct ATS communications and surveillance.

1.5 The word ‘States’ in the Plan includes Special Administrative Regions and territories.

x.xx The performance objectives of the Seamless ANS Plan are expected to be implemented in several phases:

- Phase I, expected implementation by 12 November 2015 (past);
- Phase II expected implementation by 07 November 2019 (past);
- Phase III expected implementation by 03 November 2022 (past);
- Phase IV expected implementation by 27 November 2025; and
- Phase V expected implementation by 23 November 2028.

x.xx No phase, nor any element, is binding on any State, but should be considered as a planning framework. The Seamless ANS Plan itself is therefore guidance material.

1.6 It is important to note that the Plan’s Phase commencement dates are planning targets, and should not be treated like a ‘hard’ date such as the example of the implementation of Reduced Vertical Separation Minimum (RVSM). In this case, there is a potential major regional problem if all States did not implement at the same time by the specific agreed date, which was clearly not the case for the start of the Plan’s Phases I, II or III.

1.7 In that regard, although it would have been ideal if all States achieved capability on day one of each Phase I, this was probably not realistic. However, States should consider the impact on stakeholders and improving capacity of the ATM system overall by not achieving target implementation dates. The Plan’s Phase dates were chosen as being an achievable target for the majority of States. However, the dates were not designed to accommodate the least capable State, otherwise the region as a whole would fall behind the necessary urgent ATM improvements required by the Director’s General of Civil Aviation and the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG).

Plan Review

1.8 The Plan needs to be updated to take into account ASBU Block 1, 2 and 3 modules, when these modules and their associated technology become mature.

1.9 Periodic updates to the Plan are also required in respect of the economic information contained therein.

1.10 As an iterative process, the Plan requires regular updating to keep current with aviation system changes. It is intended that APANPIRG and its contributory bodies conduct a complete review of the Plan every three years (or a shorter period determined by APANPIRG) of the Plan to align with the review cycle of the GANP. The Plan and its subsequent revisions should be endorsed by APANPIRG.

x.xx The previous practice of scheduling Plan updates to coincide with the GANP cycle and the approval of the GANP update by the ICAO Assembly presented a significant challenge to the Asia/Pacific Region in terms of fully analyzing and comprehending GANP changes which may be still under final development quite late in the cycle, and then identifying and prioritizing GANP elements

for regional implementation while developing any proposed regional planning elements in parallel. The 2019 update of the Seamless Plan included consideration of the major GANP update which was still being finalized during that year and had not yet been approved by the ICAO Assembly.

X.xx APANPIRG/33 (December 2022) agreed that the three-year update cycle of the Plan continue to be aligned with GANP updates, with each Plan update to be developed and endorsed in the year immediately following the scheduled meetings of the ICAO Assembly (**Figure X**).

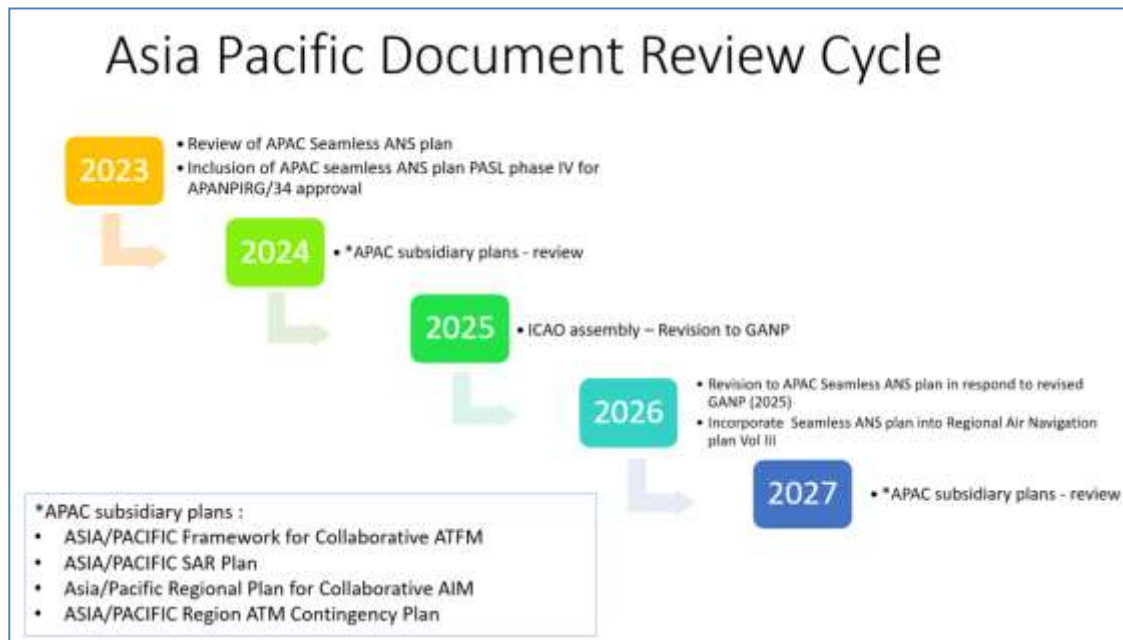


Figure X: Planned Review and Update Process

1.11 Review of the Navigation and Surveillance strategies needs to result in the update to the Seamless ANS Plan to ensure consistency.

1.12 The review of the Plan during 2019 ~~deletes~~ deleted reference to Phase I as Phase II commenced in November 2019, although the uncompleted elements from Phase I were moved to Phase II. The implementation dates of Phase II PARS and PASL items align with the GANP Block 1 implementation, whereas Phase III is a mid-Block update scheduled for 2022.

x.xx Due to the unavailability of an implementation reporting mechanism since 2019, Phase II elements are retained in this version of the Plan. With the expected availability of an updated reporting mechanism from 2023/2024, it is envisaged that uncompleted elements from Phase II will be incorporated in Phases II and III will be incorporated in the 2026 update of the Plan.

1.13 The ~~2019~~ 2023 update of the Plan introduces new ASBU Block 1 modules in Phase IV, and Block 2 modules in Phase V. Phase III and Phase IV of the PARS and PASL implementation framework will also be referenced.

PLAN OBJECTIVES AND DEVELOPMENT

Plan Objective

2.1 The objective of the Plan is to facilitate Asia/Pacific Seamless ANS operations, by developing and deploying ATM solutions capable of ensuring safety and efficiency of air transport throughout the Asia/Pacific region. The Plan provides a framework for a transition to a Seamless ANS environment, in order to meet future performance requirements.

2.2 The Plan provides the opportunity for the Asia/Pacific region to adopt the benefits from research and development conducted by various States including the NextGen programme (United States of America), the European Single European Sky ATM Research (SESAR), and Japanese Collaborative Actions for Renovation of Air Traffic Systems (CARATS).

2.3 ICAO Doc 9854 contains a vision of an integrated, harmonized, and globally interoperable ATM System, with a planning horizon up to and beyond 2025. In this context, the Plan is expected to encourage more partnering relationships among States within sub-regions.

Hierarchy of Plans

2.4 The Plan was developed as part of a suite of Asia/Pacific air navigation plans, and thus, the Plan should not be considered in isolation. The *Asia/Pacific Regional Air Traffic Flow Management (ATFM) Framework*, *Asia/Pacific Plan for Collaborative AIM*, *Regional ATM Contingency Plan*, *Asia/Pacific Search and Rescue (SAR) Plan* and *Asia/Pacific Airport Collaborative Decision Making (A-CDM) Implementation Plan* all form part of the aforementioned suite of planning and guidance material connected to the Plan (**Figure 1**).

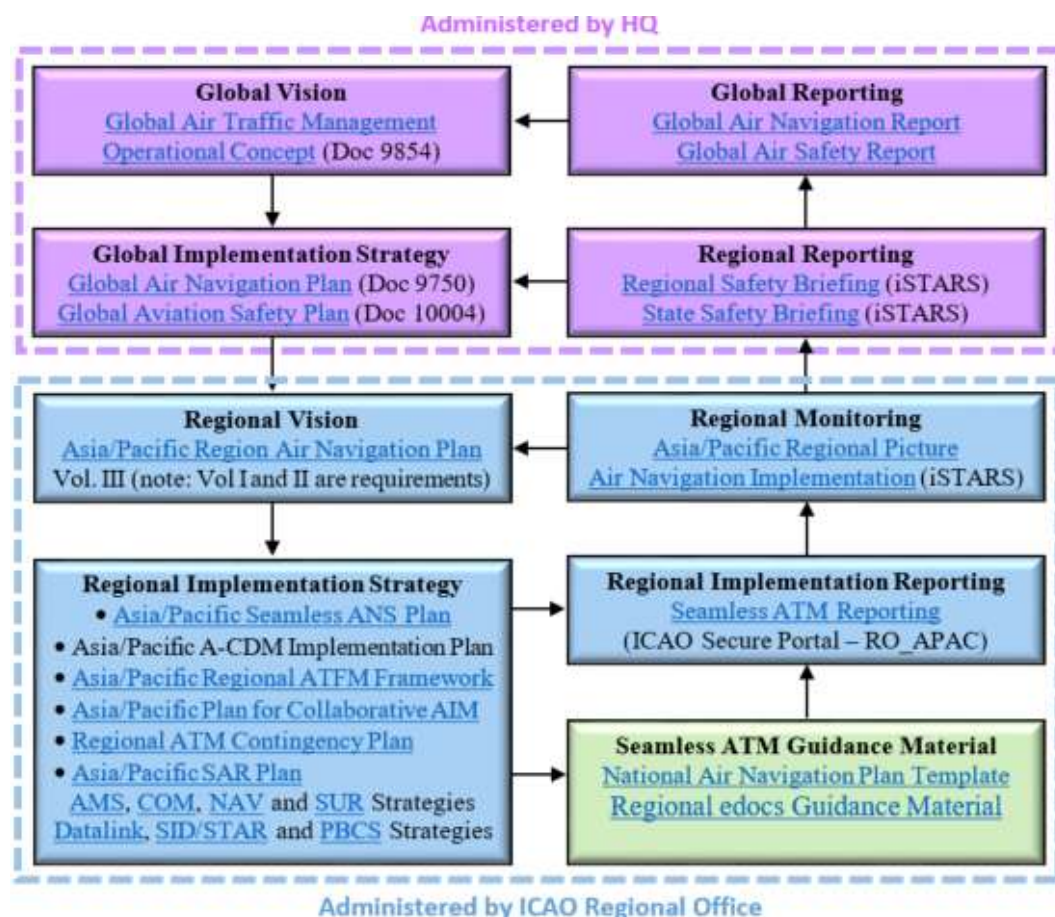


Figure X: Structure of Global and Regional Planning and Reporting

2.5 The Plan should also be read in conjunction with the Asia/Pacific Regional Aviation Safety Plan 2020-2022 edition (RASP-AP), to ensure the safety initiatives related to ANS are taken into account.

2.6 This Plan addresses the full range of ATM stakeholders, including civil and military Air Navigation Services Providers (ANSPs), civil and military aerodrome operators as well as civil and military airspace users. The Plan has been developed in consultation with Asia/Pacific States, administrations and also with International Organizations (IOs).

Note: civil airspace users include scheduled aviation, business aviation, general aviation and Unmanned Aircraft System (UAS) operators.

2.7 States should consult with stakeholders and determine actions, in order to commit to achieving the objectives of Seamless ANS and the requisite performance objectives in the areas of safety, environment, capacity and cost-efficiency that flow from this Plan.

2.8 ASBU Block 0 modules contained technologies, systems and procedures which were expected to be available from 2013. The Plan also has references to ASBU Block 1 and 2 and 3 modules, which are expected to be available from 2019 and 2025 and 2031 respectively. Where such technology, systems, standards and procedures are available earlier than these dates and appropriate deliverables can be provided, the intention was to develop aggressive yet practical implementation schedules within this Plan in order to provide the earliest possible benefits.

2.9 The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Doc 9883) provides guidance on implementing a performance-oriented ATM System. The *Manual on ATM System Requirements* (ICAO Doc 9882) contains eleven Key Performance Area (KPA) system expectations, as well as a number of general performance-oriented requirements. In accordance with the expectations of these documents, the Asia/Pacific Seamless ATM Planning Group (APSAPG) developed the following performance objectives to facilitate Seamless ANS operations:

- a) Preferred Aerodrome/Airspace and Route Specifications (PARS); and
- b) Preferred ATM Service Levels (PASL).

2.10 The PARS/PASL introduced two Performance Objectives, which incorporate system expectations, such as general performance-oriented requirements. Each performance objective is composed of a list of expectations of different aspects of the aviation system.

2.11 In considering the planning necessary before the PARS/PASL Phase dates, it is important to ensure everyone in the planning process is aware that the necessary groundwork and capability building must take place as a priority, and that full operational capability by the Phase date commencement was a secondary consideration. It is recognised that some States would be working towards implementation during the Phase, in an effort to implement as soon as possible, and others that implemented as soon as the technology and systems were available.

2.12 Prior to implementation, each State should verify the applicability of PARS and PASL by analysis of safety, ATM capacity requirements to meet current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet the expectations of stakeholders. The PARS/PASL elements would be either:

- a) not applicable; or
- b) already implemented; or
- c) not implemented.

2.13 The PARS and PASL were expected to be implemented in ~~four~~ **five** phases; Phase I by 12 November 2015 (past), Phase II by 07 November 2019 (past), Phase III by 03 November 2022 and Phase IV ~~in~~ by 27 November 2025, and Phase V by 23 November 2028.

2.14 The PARS contains expectations for airspace and ATS routes, including aircraft equipage to facilitate Seamless ANS operations, and are primarily for the State regulator and airspace authority, and are of interest to airspace planners, flight procedure designers and aircraft operators.

2.15 The PASL contain the expectations for Air Navigation Service Providers (ANSP), and is therefore a matter for the State regulator or the ATS authority. The PASL is of primary interest to ANSPs and aircraft operators. The PARS and PASL together form the foundation of Seamless ANS development, and as such should be enabled by national regulations, rules and policies wherever applicable to enable a harmonised effort by all stakeholders.

x.xx The planned migration of this Plan into the Regional Air Navigation Plan Volume III may require a review of the PARS/PASL structure.

Seamless ~~ATM~~ ANS Definition

2.16 The objective of Seamless ~~ATM~~ ANS (**previously Seamless ATM**) was agreed by the Asia/Pacific Seamless ATM Planning Group (APSAPG) as follows:

The objective of Seamless ATM is the safe and interoperable provision of harmonized and consistent air traffic management service provided to a flight, appropriate to the airspace category and free of transitions due to a change in the air navigation service provider or Flight Information Region.

2.17 APSAPG noted the following description as the CANSO definition of Seamless ATM:

Seamless ATM operations is defined as ATM operations in contiguous airspace that is technically and procedurally interoperable, universally safe, and in which all categories of airspace users transition between Flight Information Regions, or other vertical or horizontal boundaries, without requiring a considered action to facilitate that transition and without any noticeable change in:

- 1) Type or quality of service received;*
- 2) Air navigation and communications performance standards; and*
- 3) Standard practices to be followed.*

Note: the term 'Seamless ATM' was amended to 'Seamless ANS' in 2019, to reflect the fact that there are areas such as aerodromes that are not part of the Air Traffic Management field.

2.18 The ICAO Twelfth Air Navigation Conference (AN-Conf/12, Montreal, 19-30 November 2012) endorsed 10 High Level Air Navigation Policy Principles in the GANP, and the Asia/Pacific Seamless ANS Principles are aligned with these high level principles.

EXECUTIVE SUMMARY

Seamless ANS

3.1 Aviation is a significant driver of economic growth in the and contributes strongly to the economic wellbeing of the diverse cultures and people in the Asia/Pacific region. In 2016 aviation contributed USD684 billion in economic activity and generated 30.2 million jobs (Direct and indirect) to the regional economies. By 2030 it is forecast these figures will grow to USD 1.3 trillion and 70 million jobs.

3.2 Preliminary data from IATA for 2018 showed that Revenue Passenger Kilometres (RPKs) or passenger demand was strongest in the Asia/Pacific Region at 8.6%, outstripping the global industry total at 6.6% (**Figure 3**). The Region also had the largest share of Passenger Kilometres Performed (PKP), accounting for more than one third of the global total at 34.5%. Europe and North America were the two other key regions, with shares of 26.7% and 22.4% respectively (**Figure 4**).

3.3 Asia Pacific airlines flew 2,847 billion RPKs in 2018, compared with 2,207 and 1,854 for European and North American carriers respectively.

3.4 As the world's major manufacturing and distribution hub, the Asia/Pacific Region also accounted for the largest share of global air freight traffic in 2018, at 35.5%. In a challenging year for air freight, following the global inventory restocking cycle in 2017 as well having to face a number of headwinds including a moderation in world trade and deterioration in some of the key leading indicators, the Asia/Pacific region grew Freight Tonne Kilometres (FTKs) at a pace of 1.8%, below the global industry figure of 3.5% for the year.

3.5 Over the next twenty years commencing 2019, the number of passenger journeys to, from and within the Asia/Pacific Region ~~was~~ **were** expected to increase at an average annual rate of 4.8% per year. This was the fastest growing of all regions, exceeding, by some margin, the expected global growth rate of 3.5% per year. This would result in more than 2.35 billion additional air passenger journeys per year in 2037 compared with 2017.

COVID-19 Impact

x.xx The impact of the coronavirus (COVID-19) pandemic had a severe impact on the aviation industry in the Asia/Pacific Region during 2020 – 2023. In 2019, international travel within Asia represented 13.3 percent of global international travel, ranking it as second biggest market after the intra-Europe market. In 2021 Asia's share fell to 1.5 percent. Air Traffic in Asia-Pacific region was predicted to record only slow improvement in 2022, achieving only 62% of 2019 levels.

x.xx “Lost” travel between 2020 and 2022 was equivalent to 1.8 x 2019 Revenue Passenger Kilometres (RPKs) and by 2040, if 2022 forecasts are realized, traffic may still be 6% below pre-pandemic forecasts. However, after a slow start, post COVID-19 recovery remains on track despite several obstacles, both predicted and unforeseen. Overall RPKs are currently (2023) at 84% of 2019 levels.

x.xx The aviation industry is expected to recover to 2019 levels in 2024. Domestic and international passenger numbers are expected to recover to 2019 levels in 2024 and 2025 respectively. Asia Pacific lags behind other regions' recovery in the short term with the regional split showing North America in the lead, in 2023, followed by Europe and the Middle East in 2024, and Latin America, Africa, and Asia Pacific in 2025. Asia Pacific is forecast to lead traffic growth in the longer term (2040 horizon) surpassing other regions by 2028.

3.6 Given the size and diversity of the region, ATM harmonisation efforts will require the needs of the least developed ANSPs to be addressed especially in the areas of technical assistance such as funding, expertise and training. Differences in economic development may also mean that traffic demands are not uniform in the region, and therefore ATM solutions should be driven by analysis of costs and benefits and performance requirements appropriate to the traffic demands.

3.7 The diverse operating environments also mean that the implementation situation varies significantly across States. As such, the economic analysis of implementation activities such as ASBUs should be undertaken by States, and assisted by the Plan, ~~which provides high-level guidance for the development of cost-benefit analysis of implementation activity.~~

3.8 **Figure 2, Figure 3, Figure 4 and Figure 5** indicate the projected economic and air traffic growth which has necessitated the Seamless ANS approach.

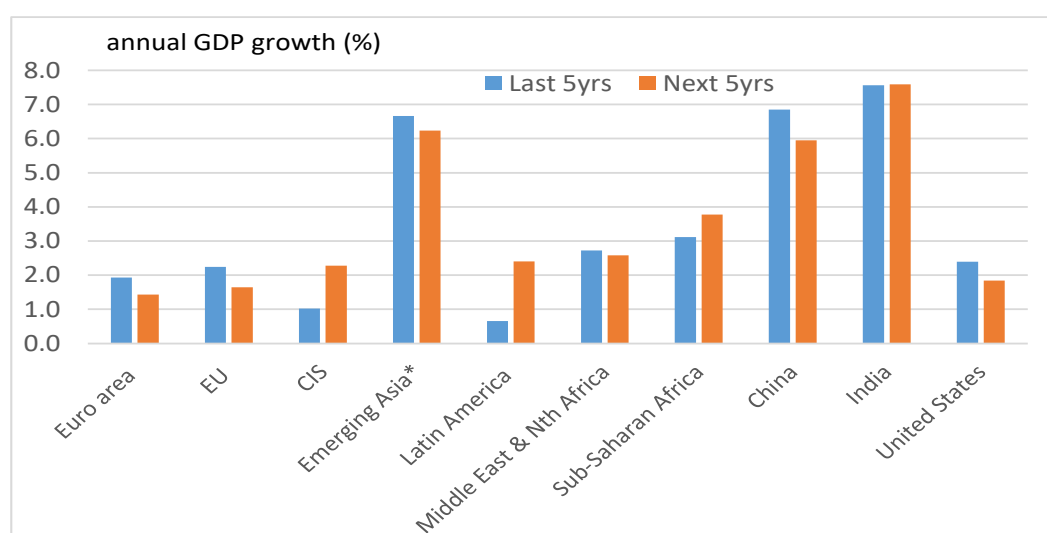


Figure 2: Regional Economic Growth (Source: IMF)

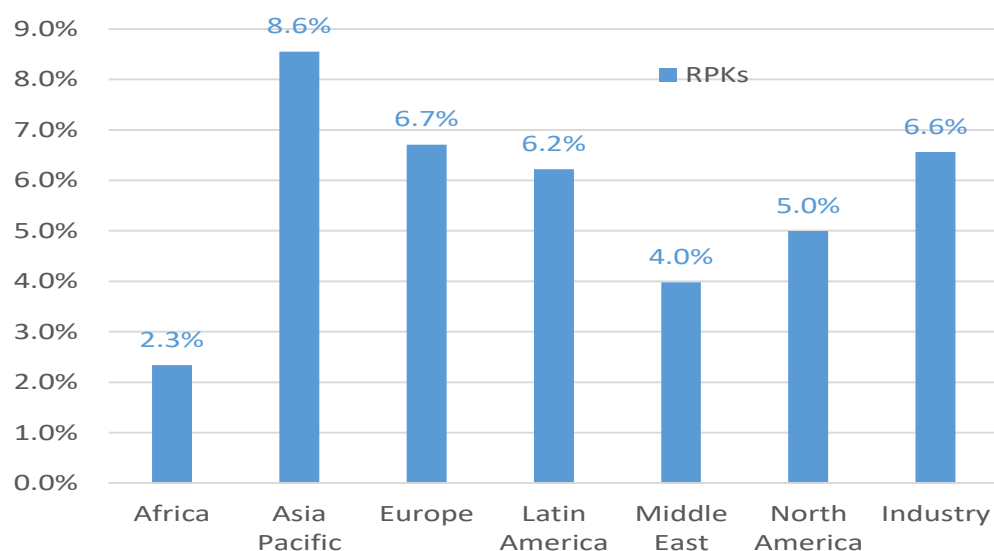


Figure 3: Regional Passenger Traffic Growth, 2018 (Source: IATA)

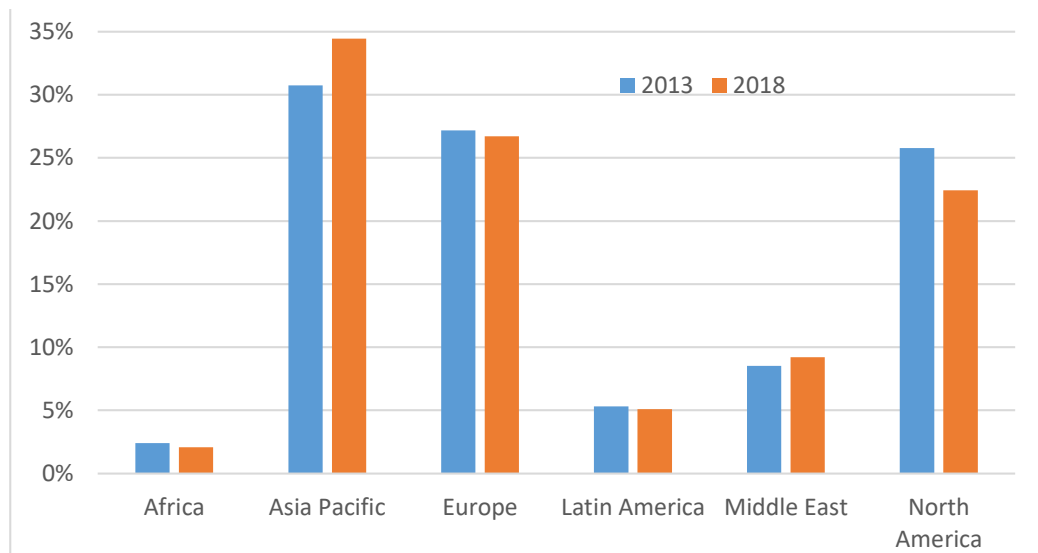


Figure 4: Regional Share of Passenger Traffic, 2013 compared to 2018 (Source: IATA)

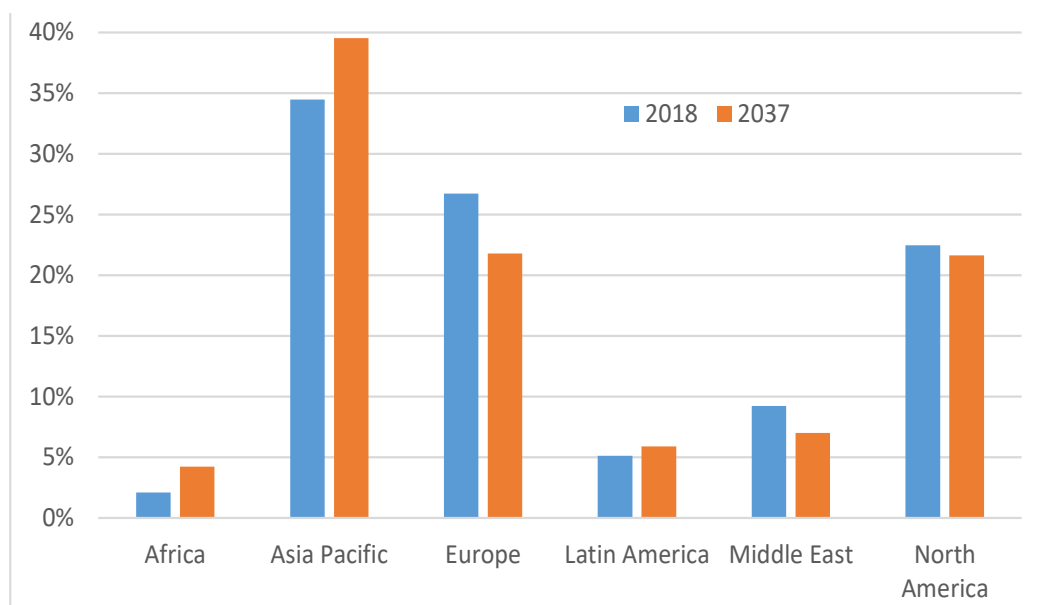


Figure 5: Regional Passenger Traffic Forecast Percentage, 2018 compared to 2037

3.9 The 46th Directors General Civil Aviation (DGCA) Conference (DGCA/46, Osaka, Japan, October 2009) was the genesis of Asia/Pacific Seamless ANS discussion, endorsing the Kansai Statement (**Appendix A**). The DGCA Conference requested the that Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) to take a lead role in development of Seamless ATM in the Asia/Pacific region.

3.10 The ICAO Asia/Pacific (APAC) Seamless ANS Symposium and Ad Hoc Meeting (Bangkok, Thailand, 15 to 17 August 2011) had developed:

- a) proposed APSAPG objectives;
- b) draft Seamless ANS principles;
- c) Civil Military cooperation Seamless ANS aspects;
- d) the requirement for ASBUs to form a key part of Seamless ANS planning; and
- e) the requirement for a capabilities matrix to provide a target and means of progressing

~~to the Seamless ANS objectives.~~

3.11 APANPIRG/22 created the APSAPG in 2011 under Decision 22/56, with a primary goal to develop an *Asia/Pacific Seamless ATM Plan*. APANPIRG/24 (2013) adopted version 1 of the Plan.

3.12 The Global Air Navigation Industry Symposium (GANIS, Montréal, 20-23 September 2011) introduced the ASBU concept. This inferred an iterative improvement, from Block 0 (zero) to 3. Although the implementation of all ASBU elements is not mandatory, it is intended to achieve the highest level of conformance; thus supporting global interoperability and Seamless ANS.

3.13 Subject to several recommendations (~~Appendix B~~), the AN-Conf/12 endorsed the ASBU concept and the consequential changes to the GANP. The AN-CONF/12 stressed that ASBU implementation and requirements needed to be coordinated at a regional level based on operational requirements, and that action plans to address identified impediments to ATM modernization should be developed. This Plan is part of the Asia/Pacific strategy to address the requirement for action plans, and to guide Asia/Pacific administrations in their ATM planning.

x.xx At the first ICAO APAC Ministerial Conference on Civil Aviation, held in Beijing, China in January 2018, the Ministers in charge of civil aviation representing 36 APAC governments endorsed the *Beijing Declaration*, formalizing their shared commitments to high-priority aviation safety and efficiency objectives (**Appendix A**). They agreed to pursue cooperative progress on objectives relating to aviation safety oversight, State Safety Programme (SSP) implementation, airport certification, independence of accident investigation authority, the timely implementation of the Asia/Pacific Seamless Air Traffic Management Plan, and the sharing of information and best practices for air navigation and search and rescue services.

Note: Beijing Declaration commitments to ANS implementation are expected to be updated by the declaration of the Second ICAO APAC Ministerial Conference on Civil Aviation, scheduled to be held in early 2024.

Air Navigation Service Provider Summary

3.14 The safety and efficiency of flights transcend national borders and airspace boundaries. Seamless ANS is therefore possible only if there is close regional collaboration among States, their ANSPs and all stakeholders. Cooperation is the key to success.

3.15 Given the size and diversity of the region, ATM ANS harmonisation efforts will require the needs of the least developed ANSPs to be addressed especially in the areas of technical assistance such as funding, expertise and training. Differences in economic development may also mean that traffic demands are not uniform in the region, and therefore ATM solutions should be driven by analysis of costs and benefits and performance requirements appropriate to the traffic demands.

Aerodrome Operator Summary

3.16 Aerodrome operations are a key component for Seamless ANS, especially in regard to infrastructure and operational efficiencies. The collaborative interaction of various stakeholders is important to ensure that aerodrome operations, facilities and equipment are suitable for all aircraft operators. Aerodrome operators require the airspace, ATM, aerodrome and aircraft operations to be cohesive and interoperable. This includes not only the aerodrome movement areas but the terminal and ancillary services, which may include border protection, fuel, baggage and passenger facilitation, which need to be aware of the interaction of their services with the aircraft operations.

3.17 Short, medium and long term aerodrome planning needs to take into account the seamless system so that capital investment is aligned to ATM operational efficiencies. Aerodrome development and airline changes are catalysts for changes driven by the aerodrome operator, but there is a need to ensure en-route and terminal ATS efficiencies are not impacted or lost, due to poor aerodrome infrastructure and operations. A saving in aircraft flight time can easily be eroded by lack of gates, poor taxiway-runway interface and inadequate terminal facilities. Stakeholder involvement and infrastructure changes needs to be coordinated to maximise the efficiencies from a systemic approach to aerodrome, airspace, air traffic management and aircraft operations.

ABBREVIATIONS AND ACRONYMS

AAR	Aerodrome Arrival Rate or Airport Acceptance Rate
ABAS	Aircraft Based Augmentation Systems
ABI	Advanced Boundary Information (AIDC)
ACARS	Aircraft Communication Addressing and Reporting System
ACAS	Airborne Collision Avoidance System
A-CDM	Airport Collaborative Decision-Making
ACIS	Airport Collaborative Information Sharing (ACIS)
ACC	Area Control Centre
ACP	Acceptance (AIDC)
ADIZ	Air Defence Identification Zone
ADC	Air Defence Code
ADOC	Aircraft Direct Operating Cost
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AeroMACS	Aeronautical Mobile Airport Communication System
AIDC	ATS Inter-facility Data Communications
AIGD	ICAO ADS-B Implementation and Guidance Document
AIM	Aeronautical Information Management
AIRAC	Aeronautical Information Regulation and Control
AIRB	Basic Airborne Situational Awareness
AIRD	ATM Improvement Research and Development
AIRMET	Information concerning en-route weather phenomena which may affect the safety of low-level aircraft operations
AIS	Aeronautical Information Service
AIXM	Aeronautical Information Exchange Model
AMAN	Arrival Manager
AMHS	ATS Message Handling System
AMS	Aeronautical Mobile Service
ANSP	Air Navigation Service Provider
AN-Conf	Air Navigation Conference
AOC	Assumption of Control (AIDC)
AOM	Airspace Organization and Management
AOP	Airport Operations Plan
APAC	Asia/Pacific
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APCH	Approach
APEC	Asia Pacific Economic Cooperation
APOC	Airport Operations Centre
APSAPG	Asia/Pacific Seamless ANS Planning Group
APUAS	Asia/Pacific Unmanned Aircraft System
APV	Approach with Vertical Guidance
APW	Area Proximity Warning
ASBU	Aviation System Block Upgrade
ASD	Aircraft Situation Display
ASEAN	Association of Southeast Asian Nations
ASM	Airspace Management
ASMGCS	Advanced Surface Movements Guidance Control Systems
ATC	Air Traffic Control
ATCONF	Worldwide Air Transport Conference
ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Service

ATN/OSI	Aeronautical Telecommunication Network/Open System Interconnection
ATS	Air Traffic Services
ATSA	Air Traffic Situational Awareness
ATM	Air Traffic Management
BOB	Bay of Bengal
CANSO	Civil Air Navigation Services Organization
CARATS	Collaborative Actions for Renovation of Air Traffic Systems
CDM	Collaborative Decision-Making
CCO	Continuous Climb Operations
CDO	Continuous Descent Operations
CDP	Climb Decent Procedure
CFIT	Controlled Flight into Terrain
CLAM	Cleared Level Adherence Monitoring
COM	Communication
CONOPS	Concept of Operations
CNS	Communications, Navigation, Surveillance
CPAR	Conflict Prediction and Resolution
CPDLC	Controller Pilot Data-link Communications
CPWG	Cross-Polar Working Group
CSP	Communication Service Provider
CTA	Control Area
CTR	Control Zone
DARP	Dynamic Airborne Re-route Planning
DCL	Data-link Departure Clearance
DGCA	Conference of Directors General of Civil Aviation
DMAN	Departure Manager
DME	Distance Measuring Equipment
EST	Coordinate Estimate
EVS	Enhanced Vision System
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FDPS	Flight Data Processing System
FIR	Flight Information Region
FIRB	Flight Information Region Boundary
FL	Flight Level
FLAS	Flight Level Allocation Scheme
FLOS	Flight Level Orientation Scheme
FRMS	Fatigue Risk Management System
FUA	Flexible Use Airspace
GANIS	Global Air Navigation Industry Symposium
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan
GBAS	Ground-based Augmentation System
GDP	Gross Domestic Product
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPI	Global Plan Initiative
HF	High Frequency
HFDL	High Frequency Data Link
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IM	Interval Management Procedure
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation Systems

IO	International Organizations
IPACG	Informal Pacific ATC Coordinating Group
ISPACG	Informal South Pacific ATS Coordinating Group
ITP	In-Trail Procedure
IWXXM	ICAO meteorological information exchange model
KPA	Key Performance Area
LNAV	Lateral Navigation
LVO	Low Visibility Operations
MET	Meteorological
METAR	Aerodrome routine meteorological report (<i>in meteorological code</i>)
MLAT	Multilateration
MON	Minimal Operating Networks
MSAW	Minimum Safe Altitude Warning
MTCD	Medium Term Conflict Detection Tool
MTF	Major Traffic Flow
MWO	Meteorological Watch Office
NANP	National Air Navigation Plan
NAV	Navigation
NextGen	Next Generation Air Transportation System
NOPS	Network Operations
NSS	Non Cooperative Surveillance Radar
OPMET	Operational Meteorological (<i>information</i>)
OLDI	On-Line Data Interchange
OTS	Organised Track System
PACOTS	Pacific Organized Track System
PARS	Preferred Aerodrome/Airspace and Route Specifications
PASL	Preferred ANS Service Levels
PBN	Performance-based Navigation
PIA	Performance Improvement Area
PinS	Point in Space
PKP	Passenger Kilometres Performed
PVT	Passenger Value of Time
RAIM	Receiver Autonomous Integrity Monitoring
RAM	Route Adherence Monitoring
RANP	Regional Air Navigation Plan
RASMAG	Regional Airspace Safety Monitoring Advisory Group
RPAS	Remotely Piloted Aircraft System
RPK	Revenue Passenger Kilometres
RNAV	Area Navigation
RNP	Required Navigation Performance
RVSM	Reduced Vertical Separation Minimum
SAARC	South Asian Association for Regional Cooperation
SATVOICE	Satellite Voice Communications
SAR	Search and Rescue
SB ADS-B	Space Based ADS-B
SBAS	Satellite-based Augmentation System
SCS	South China Sea
SESAR	Single European Sky ATM Research
SHEL	Software, Hardware, Environment and Liveware
SID	Standard Instrument Departure
SIGMET	Information concerning en-route weather phenomena in the atmosphere which may affect the safety of aircraft operations
SPECI	Aerodrome special meteorological report
SB ADS-B	Space-Based ADS-B

SSR-DAPS	Secondary Surveillance Radar Downlink of Aircraft Parameters
STAR	Standard Terminal Arrival Route or Standard Instrument Arrival (Doc 4444)
STCA	Short Term Conflict Alert
STS	Special Handling Status
SUA	Special Use Airspace
SUR	Surveillance
SVGS	Synthetic Vision Guidance Systems
SWIM	System-Wide Information Management
TAF	Aerodrome Forecast
TAWS	Terrain Awareness Warning Systems
TBO	Trajectory Based Operations
TCAC	Tropical Cyclone Advisory Centre
TCAS	Traffic Collision Avoidance System
TOC	Transfer of Control
UAS	Unmanned Aircraft Systems
UAT	Universal Access Transceiver
UPR	User Preferred Routes
VHF	Very High Frequency
VAAC	Volcanic Ash Advisory Centre
VDL	VHF Data Link
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOLMET	Meteorological information for aircraft in flight
VOR	Very High Frequency Omni-directional Radio Range
VSA	Visual Separation on Approach
VSAT	Very Small Aperture
WAFC	World Area Forecast Centre

BACKGROUND INFORMATION

Principles

5.1 There were considered to be three major areas of Seamless ANS Principles, involving People (human performance), Facilities (physical equipment), and Technology and Information. The 37 Principles agreed by APSAPG and endorsed by APANPIRG are included as **Appendix G B**.

Aviation System Block Upgrade (ASBU)

5.2 At the Global level, ICAO started the ASBU initiative as a programme framework that developed a set of aviation system solutions or upgrades intended to exploit current aircraft equipage, establish a transition plan and enable global interoperability. ASBUs comprised a suite of modules organised into flexible and scalable building blocks, where each module represented a specific, well bounded improvement. The building blocks could be introduced and implemented in a State or a region depending on the need and level of readiness, while recognizing that not all the modules were required in all airspaces. ASBUs described a way to apply the concepts defined in the Doc 9854 with the goal of implementing regional performance improvements, and were used in the new edition of the GANP to guide implementation. AN-Conf/12 agreed that the ASBUs and the associated technology roadmaps were integral parts of the GANP and a valuable implementation tool kit.

~~5.3 ICAO estimated that US\$120 billion would be spent on the transformation of air transportation systems in the period from 2013 to 2023. While NextGen and SESAR accounted for a large share of this spending, parallel initiatives were underway in many areas including the Asia/Pacific region, North and Latin America, Russia, Japan and China. ATM modernization is a very complex but necessary task, given the benefit of these initiatives as traffic levels increased. It is clear that to safely and efficiently accommodate the increase in air traffic demand — as well as respond to the diverse needs of operators, the environment and other issues, it is necessary to renovate ATM systems, in order to provide the greatest operational and performance benefits. States and ANSP must assess current domestic and international system performance needs to prioritize appropriate ASBU elements.~~

5.4 ASBU are comprised of a suite of modules, each having the following qualities:

- a clearly-defined measurable operational improvement and success metric;
- necessary equipment and/or systems in the aircraft and on the ground along with an operational approval or certification plan;
- standards and procedures for both airborne and ground systems; and
- a positive business case over a clearly defined period of time.

5.5 ASBU are groups of operational improvements to advance air navigational capabilities and improve the performance of their air navigation system in a cost effect way. They are classified into three functional categories:

- Information;
- Operational; and
- CNS Technology and Services.

Asia/Pacific ASBU Implementation

5.6 **Table 1** provides a summary of the Block 0 and Block 1 elements, and the expected priority for implementation within the Asia/Pacific Region. The allocation of priority was based on factors including its importance in promoting Seamless ANS:

- Priority 1 = critical upgrade assignment based on whether the implementation of an element could bring most benefit to the region or regional upgrade by States and is essential to achieve the service level required globally;
- Priority 2 = recommended upgrade for those elements which would bring benefits to the region and generally to be implemented from 2022, but States are encouraged to implement earlier if beneficial; and
- Priority 3 = assigned to those elements which may not be universally implemented in the Asia/Pacific Region.

5.7 A cost-benefit or economic analysis before implementation was identified as essential to determine whether to implement certain elements such as SURF-B0/1/1-4, but should not preclude an economic analysis of other elements as determined by the State. Detailed information on the development, scope, objectives, stakeholders and dependencies for each ASBU element is provided at <https://www4.icao.int/ganpportal/>.

Functional Category	Element	Description	Priority	Responsibility for Review, Endorsing and Monitoring
Information	AMET B0/1-4	Meteorological observations, forecast, warning, climatological and historical products, and dissemination	1	MET SG
	AMET – B1/1-4	Meteorological products supported by automated decision systems or aids using IWXXM	2	
	AMET-B2/1 to B2/4	Integrated meteorological observations in support of enhanced ATM and airport decision-making processes, particularly in the near-term.	3	MET SG
	DAIM-B1/1 – 6:	Provision of quality-assured digital aeronautical data and information, including AIP, terrain and obstacle, aerodrome and instrument flight procedure data sets	1	ATM SG
	DAIM-B1/7	Provision of digital NOTAM improvements	2	
	DAIM-B2/1 to B2/5	Integrated aeronautical information service in a SWIM environment in support of enhanced operational ground and air decision-making processes for all phases of flight.	3	
	FICE-B0/1:	Automated basic AIDC	1	CNS SG

	FICE-B2/1-B2/9	To enhance ATS flight plan processing including constraints evaluation and enhanced flight information sharing.	3	CNS SG ATM SG
Operational	ACDM-B0/1-2:	ACIS	1	ATM SG
	ACDM-B1/1 – 2:	Airport CDM Integration with ATM Network, AOP and APOC	2	AOP SG ATM SG
	ACDM-B2/1-3:	AOP, APOC and Total Airport Management	3	AOP SG
	APTA-B0/1 – 2:	Basic PBN SID and STAR procedures, PBN non-precision approaches	1	CNS SG
	APTA-B0/3 and 6	SBAS/GBAS CAT I precision approach procedures, and PBN Helicopter PinS Operations	3	
	APTA-B0/4 – 5, 7 – 8:	CDO (Basic) and CCO (Basic), and performance-based aerodrome operating minima for advanced/basic aircraft	2	
	APTA-B1/1 – 5:	advanced capability PBN approaches, PBN SID and STAR procedures and performance-based aerodrome operating minima for advanced aircraft with SVGS, CDO and CCO (Advanced)	3	
	APTA-B2/1	GBAS CAT II/III precision approach procedures	3	
	APTA-B2/2	Simultaneous operations to parallel runways	3	
	APTA-B2/3	PBN Helicopter Steep Approach Operations	3	
	APTA-B2/4	Performance based aerodrome operating minima – Advanced aircraft with SVGS	3	
	CSEP-B1/1 – 4:	basic airborne situational awareness AIRB and VSA, and performance-based horizontal separations	2	ATM SG
	CSEP-B2/1 – 3:	Interval management procedure; cooperative separation at low altitudes and higher airspace	3	ATM SG
	FRTO-B0/1 – 4:	Direct routing, Airspace Planning and FUA, Flexible Routings, and basic conflict detection and conformance monitoring	1	ATM SG
	FRTO-B1/1 – 7:	Free Route Airspace, RNP routes, Advanced FUA and Airspace Management (ASM), Dynamic Sectorisation, Enhanced Conflict Detection Tools and Conformance Monitoring, and Multi-Sector Planner Function	2	
	FRTO-B2/1 – 4:	Integrated ATFM and ATC Planning; Dynamic Airspace Configuration; Cross border FRA; Enhanced Conflict Resolution Tools	3	

NOPS-B0/1 – 5:	Initial integration of ASM with ATFM, Collaborative Network Flight Updates, Basic Network Operation Planning and Initial Airport/ATFM slots, A-CDM Network Interface and Dynamic Slot Allocation	1	
NOPS-B1/1 – 10:	Short Term ATFM measures, Enhanced NOPS Planning, Enhanced integration of airport operations and NOPS planning, Enhanced Traffic Complexity Management, Full integration of ASM with ATFM, Initial Dynamic Airspace configurations, Enhanced ATFM slot swapping, Extended Arrival Management, ATFM Target Times and Collaborative Trajectory Options Programme	2	
NOPS-B2/1 -2	Optimised ATFM in initial TBO context; Enhanced Dynamic airspace configuration	3	
NOPS-B2/3	Collaborative Network operation planning	3	
NOPS-B2/4	Multi ATFM slot swapping and Airspace User priorities	3	
NOPS-B2/5	Further airport integration	3	
NOPS-B2/6	ATFM for Cross Border FRA	3	
NOPS-B2/7	UTM Network Operations	3	
NOPS-B2/8	Higher Upper airspace network operations	3	
OPFL-B0/1:	ITP	3	
OPFL-B1/1:	CDP	3	
OPFL-B2/1	Separation minima using ATS Surveillance when VHF not available	3	ATM/SG
RATS-B1/1	Remotely Operated Aerodrome Air Traffic Services	3	AOP SG ATM SG CNS SG
RSEQ-B0/1 – 2:	Arrival and Departure Management	1	ATM SG
RSEQ-B0/3	Point merge	3	CNS SG
RSEQ-B1/1	Extended arrival metering	2	ATM SG
RSEQ-B2/1	Integration of Arrival and departure Management	3	

	SNET-B0/1 – 4	STCA, MSAW, APW, APM	1	CNS SG ATM SG
	SNET-B1/1 – 2:	Enhanced STCA with aircraft parameters and in complex TMAs	2	
	SURF-B0/1 – 3:	Basic ATC surface operations tools, comprehensive situational awareness, situational awareness, alerting service	2	CNS SG ATM SG
	SURF-B1/1 – 5:	Advanced surface traffic management visual aids, pilot comprehensive awareness and runway alerting, enhanced ATC alerting, routing service to support ATC and EVS for taxiing	2	
	SURF-B2/1 - B2/3	Enhanced surface guidance for pilots and vehicle drivers; Conflict alerting for pilots for runway operations	3	AOP SG CNS SG
	TBO-B0/1:	Introduction of time-based management within a flow centric approach	2	ATM SG CNS SG
	TBO-B1/1 –	Initial Integration of time-based decision-making processes	2	
	TBO-B2/1- B2/2	Pre departure Trajectory synchronization; extended Time based management across multiple FIRs.	3	
	WAKE-B2/1-2	Wake Separation Minima based on 7 aircraft groups; Time based Wake separation minima on final approach	3	ATM SG
CNS Technology and Services	ASUR-B0/1 – 3:	ADS-B, MLAT, SSR-DAPS	1	CNS SG
	ASUR-B1/1	Reception of aircraft ADS-B signals from space (SB ADS-B)	2	
	ASUR-B2/1	Evolution of ADS-B and Mode S	3	
	ASUR-B2/2	Community based surveillance system for airborne aircraft (low and higher airspace)	3	
	COMI-B0/1 – 2, 4 – 6:	ACARS, ATN/OSI, VDL Mode 2 Basic, SATCOM Class C Data, HFDL	2	
	COMI-B0/3, 7:	VDL Mode O/A, AMHS	1	
	COMI-B1/1 – 4:	VDL Mode 2 Multi-Frequency, SATCOM Class B (SB-S) Voice and Data, ATN/IPS and AeroMACS Ground-Ground	2	
	COMI-B2/1 -3	Air Ground ATN/IPS, AeroMACS, Links for non-safety communication	3	

COMS-B0/1 – 2:	CPDLC (FANS 1/A & ATN B1) for domestic and procedural airspace and ADS-C (FANS 1/A) for procedural airspace	2	
COMS-B1/1 – 3	: PBCS approved CPDLC (FANS 1/A+), ADS-C and SATVOICE for domestic and procedural airspace	2	
COMS-B2/1-3	PBCS approved CPDLC, ADS-C, SATVOICE	3	
NAVS-B0/1 – 4:	SBAS, GBAS, ABAS, MON	2	
NAVS-B1/1:	Extended GBAS	3	
NAVS-B2/1-3	DFMC- GBAS, SBAS, ABAS	3	
SWIM-B2/1 -5	SWIM Services and Global SWIM Processes	3	

Table 1: Asia/Pacific ASBU Block 0 and, Block 1 and Block 2 Priority

Implemented Elements

5.8 The following ASBU Block 0 elements were considered to be almost universally implemented within the APAC Region in terms of being established Annex 6 standards (ACAS) by or in the early stages of Block 1 from 2019 (GADSS), so were not referenced as a priority in Table 1:

- **ACAS-B1/1:** ACAS Improvements (TCAS Version 7.1); and
- **GADS-B1/1 – 2:** Aircraft Tracking and Contact directory service (PASL 7.42).

Regional Elements

5.9 The Regional elements were incorporated into the Seamless ANS framework used to assess the uptake by Asia/Pacific States.

5.10 **Table 2** provides a summary of the Regional Seamless ANS elements, and the expected priority for implementation within the Asia/Pacific Region. The allocation of priority was based on factors including its importance in promoting Seamless ANS.

Functional Category	Regional Seamless ANS Element	Priority
Operational	Aerodrome management and coordination (PARS 7.1)	2
	Optimization of runway capacity facilities (PARS 7.2)	3
	ADS-B, SSR Mode S and PBN Airspace (PARS 7.8, 7.9, 7.10)	2
	Flight Level Orientation Scheme (FLOS) (PARS 7.15)	2
	Civil-Military SUA management (PARS 7.16)	1
	Unmanned Aircraft Systems (PARS 7.17)	2
	Adjacent ATS sector coordination (PASL 7.24)	2
	Airspace classification (PASL 7.33)	2
	ATC horizontal separation (PASL 7.34)	2
	Flight Level Allocation Schemes (FLAS) (PASL 7.35)	2

	ATC sector capacity (PASL 7.37)	2
	Electronic Flight Progress Strips (PASL 7.39)	2
	Enhanced SAR systems (PASL 7.42)	1
	ANSP human and simulator performance (PASL 7.43)	4
	Civil-Military strategic and tactical coordination (PASL 7.44)	1
	Civil-Military common procedures and training (PASL 7.44)	2
	Ballistic launches/space re-entry management (PASL 7.45)	1
CNS Technology and Services	ATS surveillance data sharing (PASL 7.28)	2
	Civil-Military integrated systems and facilities (PASL 7.44)	2
	Departure Clearance (DCL) (PASL 7.49)	2

Table 2: Asia/Pacific Seamless Regional Elements Priority

5.11 There ~~are~~ were 16 Priority 1 [ASBU Block 0 and Block 1 and Regional] Elements as follows:

- a) Aeronautical Meteorology: AMET-B0/1 – 4;
- b) Aeronautical Information Management: DAIM-B1/1 – 6*;
- c) Airport CDM: ACDM-B0/1 – 2;
- d) ANSP human and simulator performance (Regional);
- e) ATS Inter-facility Datalink Communications: FICE-B0/1;
- f) Ballistic launches/space re-entry management (Regional);
- g) Civil-Military Special Use Airspace (SUA) management (Regional);
- h) Civil-Military strategic and tactical coordination (Regional);
- i) Core data communications: VDL Mode O/A and AMHS COMI-B0/3, 7;
- j) Direct and Free Route Operations: FRTO-B0/1 – 4;
- k) Enhanced SAR systems (Regional);
- l) Ground-based Surveillance: ASUR-B0/1 – 4;
- m) Network Operations: NOPS-B0/1 – 5;
- n) Performance-based Navigation Approach Procedures: APTA-B0/1 – 2;
- o) Runway Sequencing: RSEQ-B0/1 – 2; and
- p) Safety Nets SNET-B0/1 – 4.

**Note: DAIM-B1/7 is placed within PASL Phase III.*

Human Performance

5.12 The Global ATM Operational Concept (Doc 9854) states:

Humans will play an essential and, where necessary, central role in the global ATM system. Humans are responsible for managing the system, monitoring its performance and intervening, when necessary, to ensure the desired system outcome. Due consideration to human factors must be given in all aspects of the system.

5.13 The AN-Conf/12 emphasised the importance of human performance considerations by endorsing Recommendation 6/4 (~~Appendix B~~), which called for the integration of human performance as an essential element for the implementation of ASBU modules and in the planning and design phase of new systems and technologies, as part of a safety management approach.

5.14 The role of the human is especially important in delivering high quality and consistent services supporting Seamless ANS. Therefore, it is crucial to ensure that, training and licensing requirements are developed using a competency-based framework, fatigue-related risk is managed appropriately, and safety data, including the reporting of hazards, is collected, analysed and acted upon within ATM systems that support Seamless ANS. States should identify specific efficiency improvements expected from ASBU Element deployment. These expectations should include regulatory and/or procedural changes needed to optimize new capabilities.

5.15 One of the more important human performance aspects in order to deliver a consistent, harmonised and efficient service is ATC training, to change from a procedural mind set to one that used the tactical delivery of services based on ATS surveillance and automated safety net decision support tools (airborne and ground).

5.16 Moving from reliance on paper-based flight progress strips to an electronic equivalent connected to the ATS surveillance Flight Data Processing System (FDPS) or direct data inputs to the Aircraft Situation Display (ASD) support this paradigm shift. The use of paper flight progress strips in automated ATM environments reduces efficiency, increases transcription error/data mismatch, and artificially caps ATC capacity due to retention of manual tasks made redundant by the automation capability.

5.17 Controllers need to be trained on the application of tactical separation, including the use of positive control techniques, such as vectoring and speed control when conflict pairs approach minimum separation. In this regard, it is important that managers facilitate a modern operating environment in terms of air safety incidents and human factors, so personnel are confident using the full capability provided by the CNS facilities.

5.18 A critical human performance issue is the training of ANSP management and regulators in human performance issues. These decision-makers had an important influence on outcomes in terms of supporting the right environment for Seamless ANS activities, whether that is providing financial resources, or establishing high-level policies and procedures.

5.19 A key component of Seamless ANS is the ability of controllers to operate, and have confidence in, a new operating environment. The appropriate use of ATC simulators to enhance their learning experience is an essential part of the necessary training.

5.20 In planning to deliver Seamless ANS services, it is assumed that each State and aircraft operator will comply with the English language proficiency requirements in accordance with ICAO Standards and Recommended Practices. States should be considering the highest levels of English language proficiency for all operational controllers to ensure they can respond appropriately to irregular occurrences (e.g.: emergencies) by use of an internationally recognised system.

5.21 States must acknowledge the challenge of modifying current practices and procedures to incorporate and optimize improved system capability. States and ANSPs are encouraged to establish sub regional or bilateral relationships to share best practices and develop strategies to improve performance.

5.22 An optimal ‘aviation culture’ within regulators and service providers can only be implemented when top managers instil an understanding of a system-wide approach that creates an organic, learning and safe environment. When considering the key factors supporting an ‘aviation culture’, it is important to acknowledge that no ‘national culture’ is perfectly aligned with ‘aviation culture’, so there will always be a need for gap analysis and changes where development of an appropriate in culture is required. In focussing on management it is therefore important to train managers, and for managers to have a level of competency in the following areas (**Figure 6**):

- a) the advantages of a responsible, informed and accountable management, which promotes a proactive organisational culture with safety as a first priority, using open communications and a team management approach; and
- b) the implementation of an appropriate organizational culture which is effectively driven by management through embedded safety review and assessment teams, allowing the organization to respond organically to its operating environment;
- c) the systematic application of human factors principles in –
 - air safety investigation;
 - system design (ergonomics, human-in-the-loop);
 - effective training (including the use of simulators);
 - fatigue management;
 - automated safety nets; and
 - contingency planning;
- d) the implementation of effective safety reporting systems that –
 - are non-punitive, supporting a ‘Just Culture’;
 - promote open reporting to management; and
 - focus on preventive (systemic), not corrective (individual) actions in response to safety concerns, incidents and accidents.



Figure 6: Optimal Aviation Culture Factors

Civil-Military Cooperation

5.23 One of the key enablers for improvement of ATM efficiencies supported by Doc 9854 (Global ATM Operational Concept) is the use of FUA. This is an airspace management concept based on the principle that airspace should not be designated as purely civil or military, but rather as a continuum in which all user requirements are accommodated to the greatest possible extent. FUA normally referred to the activation of SUA, but could also include controlled airspace.

5.24 The establishment and operation of SUA required careful assessment, review and management, to ensure the most appropriate airspace designation is used, and the airspace is operated in a cooperative manner. This is ordinarily only possible through discussion between military and civil parties. Thus a key to the establishment of effective FUA is risk-based assessments, determining the risks or security issues involved through coordinated and cooperative methods if possible.

Note: Annex 2 Rules of the Air states that restricted areas were airspace of defined dimensions, above the land areas or territorial waters of a State, which means that restricted areas must not be designated over the high seas or in airspace of undetermined sovereignty

5.25 Restricted areas designed to segregate civil aircraft from airborne military operations or ordnance firing would be expected when the risk of an accident for non-segregated operations is higher than acceptable. However, lower risk military operations (such as using small calibre weapons at an established firing range) may only require the establishment of a danger area or even no SUA. Thus the type, dimensions, activation notice and duration of SUA activity should be appropriate and commensurate with the type of activity affecting the airspace.

5.26 APANPIRG/9 (August 1998) developed the following guidelines for Civil-Military cooperation in the following areas: military procedures, aeronautical facilities and ground services, civil and military ATS unit personnel, airspace, research and development, common terminology, abbreviations rules and procedures, military exercises, and non-sensitive military data.

- If at all possible, military training should be conducted in locations and/or at times that do not adversely affect civilian operations, particularly those associated with major aerodromes. This requires strategic planning by formal Civil-Military coordination bodies.
- Consideration of the interoperability and operations of military systems is an integral part of a Seamless ANS environment. With increasingly complex aircraft equipage civil requirements, non-compliant military or other State aircraft may become more difficult to manage using Special Handling Status (STS). The limitations or requirements of military aircraft cockpits, avionics and airframes may even preclude some civil systems, and yet military aircraft still need to transit airspace used predominantly by civil operations.
- Military participation at civil ATM meetings and within ATS Centres will often lead to a better understanding of civil needs, as well as military requirements, including the operation of Unmanned Aircraft Systems (UAS). UAS have been predominately used by the military in segregated airspace, but now many forms of State missions including customs, immigration and police operations are being planned, as well as a myriad of potential civil uses.
- Responses to Search and Rescue (SAR), Civil Defence (normally natural disaster emergencies), and national security events will inevitably require Civil-Military coordination so this needs to be taken into account during the planning for such operations.

As these occurrences could involve a number of States, regional Civil-Military planning is crucial in order to reduce the response time for emergency services to aid those in need. The response to an international aviation SAR event may well involve a location over the high seas, so all States should have SAR agreements with neighbouring nations to ensure that SAR services were unimpeded to the maximum possible extent.

5.27 The Asia/Pacific Civil-Military Cooperation Seminar/Workshop (Bangkok, 28 February to 1 March 2012) recommended that the following Civil-Military cooperation/coordination principles

and practices should be elevated to the highest political level in the Asia/Pacific regions:

- Civil-Military working arrangements should be enacted where discussion of both civil and military needs were able to be negotiated in a balanced manner;
- the importance of the interoperability of civil air transport infrastructure and national security was recognized;
- the interoperability of civil and military systems including data-sharing was emphasized; and
- regular review of controlled airspace and special use airspace was encouraged to be undertaken by States to ensure its establishment, size, activation and operation was appropriate in terms of optimal Civil-Military operations.

5.28 The Asia/Pacific Civil-Military Cooperation Seminar/Workshop requested ICAO to update existing provisions related to Civil-Military cooperation/coordination and further develop guidance material related to airspace planning and management, including FUA.

5.29 Data sharing arrangements (including aircraft surveillance), are a key part of Civil-Military cooperation for tactical operational responses, and to increase trust between civil and military units. Data sharing between the civil and military could facilitate CDM, a vital component of ATFM. The Regional Surveillance Strategy espouses Civil-Military cooperation and system interoperability.

5.30 Aircraft operating ADS-B technology transmit their position, altitude and identity to all listeners, conveying information from co-operative aircraft that have chosen to equip and publicly broadcast ADS-B messages. Thus there should be no defence or national security issues with the use and sharing of such data.

Note: Some military transponders may support ADS-B using encrypted messages, but this data is not normally decoded or used at all by civil systems. In many cases, tactical military aircraft are not ADS-B equipped or could choose to disable transmissions. In future, increasing numbers of military aircraft would be ADS-B capable, with the ability to disable these transmissions. ADS-B data sharing should not influence the decision by defence agencies to equip or not equip with ADS-B. Moreover, it is possible for States to install ADS-B filters that prevent data from sensitive flights being shared. These filters can be based on a number of criteria and typically use geographical parameters to only provide ADS-B data to an external party if aircraft were near the boundary.

5.31 The ten Civil-Military elements identified by APANPIRG are as follows:

- a) **Strategic Coordination.** This element emphasised the creation of a permanent body, facilities and procedures to facilitate long and medium-term planning for optimal civil and military operations, and the tactical coordination element. This element features the establishment of a national body that encompasses military (and State aircraft operators) and civil stakeholders, to develop high level Civil-Military cooperation policy.
- b) **Tactical Coordination.** The establishment of facilities and procedures derived from the high level strategic coordination body for the daily, safe and efficient tactical management of operations. Tactical coordination features participation of military officers at appropriate civil ATM meetings, airspace scheduling through interaction and communications between civil and military units, and military representation within civil ATC Centres where necessary.
- c) **Airspace Review.** The regular review of SUA and controlled airspace, to ensure that the means and notice of activation provide adequate warning for other airspace users,

the SUA types reflect the usage, and the lateral and vertical limits are the minimum required to safely contain the activity therein (Annex 11 2.19.2.1 (b) refers). The review of airspace should be conducted by an airspace authority independent or a collaboration of civil and military airspace users.

- d) **Flexible Use Airspace.** Mechanisms to ensure the minimisation of airspace being exclusively assigned for civil or military use in accordance with FUA principles, assessed by the percentage of military SUA within a Flight Information Region (FIR).
- e) **International Airspace.** The minimisation of SUA and other military entities that may adversely affect international airspace. Restricted and prohibited areas must not be designated within international airspace or airspace of undefined sovereignty.
- f) **Integrated Civil-Military ATM Systems.** The integration of civil and military ATM systems where practicable, including the management of civil and State UAS aircraft, policies and procedures to manage State aircraft that are non-compliant with civil requirements, systems to manage civil and military SAR units, and joint procurement of systems where possible.
- g) **Joint Civil-Military Aerodromes and Navigation Aids:** The operation of joint civil-military aerodromes if possible, and the provision of navigation aids that could be utilised by both civil and military aircraft where practical.
- h) **Shared Civil-Military Data:** The provision of ATS surveillance data from civil surveillance systems to military units to improve monitoring (thereby minimising the need for individual defence identification authorisation), trust and confidence. The provision of surveillance data from military surveillance systems where this would enhance ATS surveillance coverage and redundancy; suitably filtered as appropriate.
- i) **Common Civil-Military Training and Procedures.** The familiarisation of civil and military ATM personnel with each other's systems and procedures, where national security allows. Training and licensing of civil and military air traffic controllers to equivalent standards. The implementation of the same or equivalent standards, procedures and policies for the provision of ATS and the management of air traffic.
- j) **Ballistic Launch and Space Re-entry.** Effective coordination mechanisms established by States responsible for ballistic launch and space re-entry activities to ensure the safety of civil air navigation in the air and on the ground, with particular emphasis on how such activity affects other States in terms of safety and efficiency.

5.32 The efficient management of rocket/missile launch and space re-entry activity by both State and civil agencies is critical to minimise disruption to other airspace users. Increasingly, ballistic launch and space re-entry activity may be conducted by other State or civil/private agencies, which should conform with the same expectations in this Plan as military agencies. The coordination of all the stakeholders will be enhanced by:

- coordination agreements between the State civil aviation authority, the ANSP, and the launch/re-entry agency concerned; and
- strategic coordination conducted between the State civil aviation authority prior the activity and tactical management of the launch/re-entry activity.

5.33 A State Planning Checklist and additional guidance for ballistic launch and space re-entry activity is at <https://www.icao.int/APAC/Pages/new-eDocs.aspx>.

Airspace Equipage Mandates

5.34 From an operators' perspective, the following were important considerations:

- Preparation Time: Operators need time to prepare for any mandated equipage requirement – if new equipment is involved, several years may be required to allow fitment to take place during normal airframe maintenance cycles.
- Cost Benefit: Operational improvements, including the use of new technologies or implementing ASBUs, need to provide operational benefits that outweighed the total cost of implementation and operation. This included the airspace user side of the equation. States/ANSPs should carry out studies of the costs and benefits for all stakeholders.
- Education and promulgation: States/ANSPs should work with local airlines and International Organizations to ensure industry and other stakeholders are educated and informed regarding upcoming aircraft equipage mandates very early in the planning process. Ideally, the dialogue should begin with user consultation pertaining to the selection of appropriate solutions. Once a decision has been made, user education should include briefings, media notifications as well as required AIS promulgation.
- Service Outcomes: States/ANSPs must ensure the service delivery efficiencies enabled by an aircraft equipage mandate are actually delivered operationally coincident with the implementation date of the mandate. If service delivery is delayed, any related aircraft equipage mandate should also be delayed accordingly. States/ANSPs should consider offering operational advantages to early adopters of the desired equipage or capability to offset costs. This would enable operators to make at least partial use of the mandated capability in advance of the mandated date.
- Harmonization: it is essential that States/ANSPs harmonize requirements with neighbours as far as practicable, including implementation dates.
- Regulatory considerations: it is essential that regulators are involved very early in the planning process. Experience shows that regulatory approvals are often a problem with the introduction of aircraft equipage mandated environments.
- High Seas: Where airspace over the High Seas is affected, States must ensure appropriate ICAO processes are followed, including amendments to the required ICAO provisions.

Regulation and Safe Operation of Unmanned Aircraft Systems

5.35 ~~The Asia/Pacific UAS Task Force (APUAS/TF) was formed by APANPIRG to develop guidance material to support an Asia/Pacific Seamless ATM Plan element, including regional expectations for the regulation and safe operation of UAS that fell outside the scope of the ICAO RPAS Panel, within non-segregated airspace and from an ATM perspective published in the ATM section of the ICAO Asia/Pacific Regional Office eDocuments web page at: <https://www.icao.int/APAC/Pages/new-eDocs.aspx>.~~

5.36 ICAO Headquarters, supported by the Unmanned Aircraft Systems Advisory Group (UAS-AG), ~~had also~~ developed a global resource of information and guidance material, including:

- the UAS Toolkit, providing general guidance on such issues as UAS regulations and risk-based approaches to regulation, training and education needs and authorizations, and examples of, and links to, existing UAS regulations of 39 States; and
- a UAS Traffic Management (UTM) framework, summarizing key principles, lessons learned and best practices in the establishment of requirements for approval of UTM service providers.

Note: the UTM framework is subject to ongoing development, in line with the growth of global knowledge and experience in UTM.

5.37 The UAS Toolkit, UTM framework and other relevant information is available on the ICAO Unmanned Aviation web pages at: <https://www.icao.int/safety/UA/Pages/default.aspx>.

5.38 Considering the rapid growth of the UAS industry, and the consequent economic and social benefits arising, there is an immediate need for an aviation regulatory response to facilitate access to non-segregated airspace while protecting the safety and access to airspace of conventional airspace users. For this purpose, an Asia/Pacific regional performance expectation for the regulation of UAS is included in PARS Phase II.

CURRENT SITUATION

Aerodrome Analysis

6.1 In the 1990s and the first decade of the new millennium, aerodrome operators in Asia-Pacific invested billions of dollars to enhance capacity of existing aerodromes and to build new ones to meet increasing air traffic demand. Notable examples are the opening of Bangalore, Hong Kong, Incheon, Kuala Lumpur International, Shanghai Pudong and Suvarnabhumi airports and the expansion of New Delhi and Beijing Capital airports. The automation and the adoption of self-service technology for passenger handling such as check-in and automated border control has enabled many airports to build up capacity without expanding passenger terminal footprint.

6.2 Runways are typically the capacity bottleneck of aerodromes but aircraft parking stands, baggage sorting and transfer facilities, aprons and passenger security screening points operating close to or over capacity are becoming choke points as well, especially at hub airports. A-CDM promises to alleviate congestion but the close collaboration between airport management and other stakeholders such as its shareholder, ATM and airlines is essential to a coordinated development of the capacity of the regional air transport network in the long-term.

Implementation Progress

x.xx As a follow-up to Conclusion APANPIRG 25/5, a number of States/Administrations had reported on their Seamless ATM implementation progress. The status of the reporting process as at March 2019 is depicted in Figure 1.

Important note: the Regional Seamless reporting tool (accessible via the Regional Office website at <https://www.icao.int/APAC/Pages/ATMReport.aspx>) had not been updated by ICAO HQ to take into account the changes to the latest version of the Global Air Navigation Plan and the 2019 (version 3.0) update of the Asia/Pacific Seamless ANS Plan. The reporting status information should be treated with caution as the last data update of the current system was in March 2019.

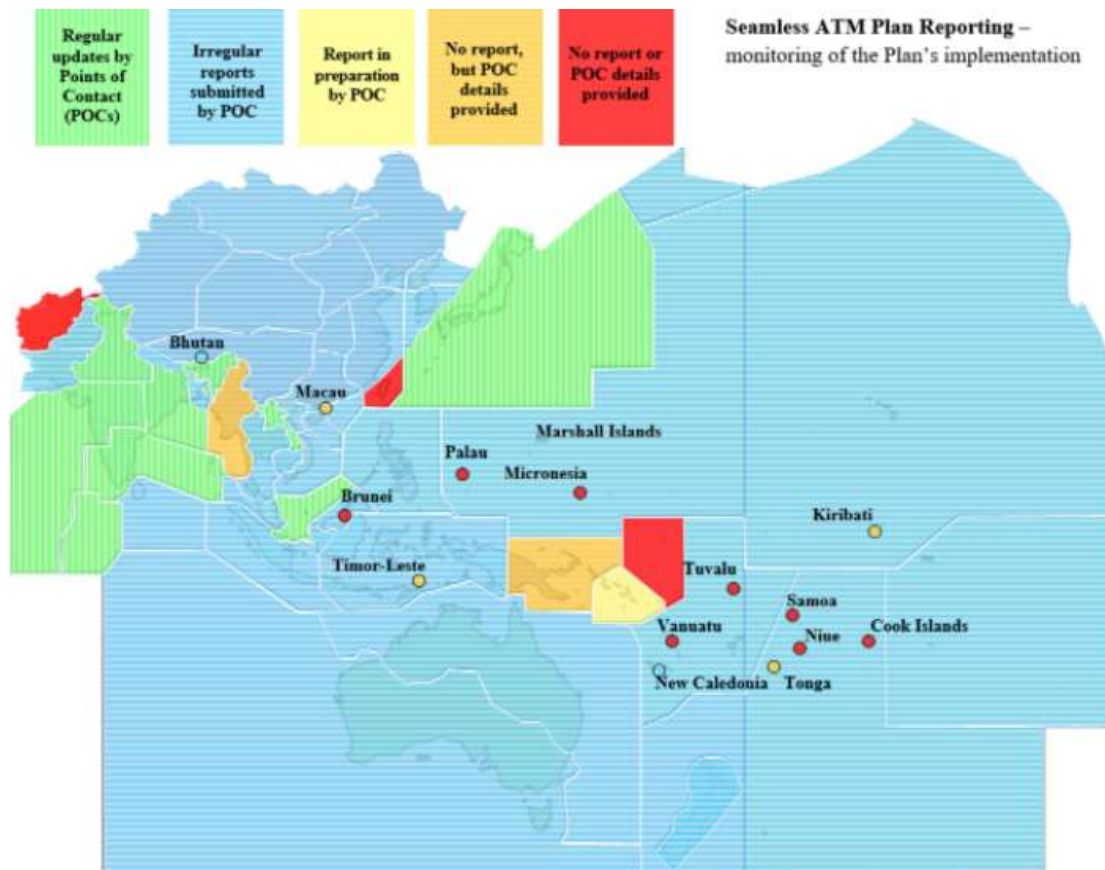


Figure X: Seamless ATM Reporting (2019)

x.xx A total of 28 States/Administrations, i.e. 63.6% of the APAC States/Administrations, had submitted one or more report(s) on the ICAO Seamless ATM Reporting Portal (accessible through the ICAO Secure Portal). Among those 28 States/Administrations, only six States had submitted at least four reports from 2014 to 2018 (note: ‘regular reporting’ is measured over the past three years).

x.xx Seamless ANS implementation data is used to support an iSTARS tool intended to illustrate ANS planning and implementation (<https://portal.icao.int/space/Pages/Catalogue.aspx>).

6.3 The progress of implementation of the Plan had been unacceptably slow, with the Plan having been endorsed by APANPIRG in 2013, and the Phase I elements expected to be at least partly implemented by the start of Phase I in November 2015, to ensure a matching of ground-based capability with that on modern aircraft systems. However, as at March 2019, the implementation progress by States and Administrations that had been reporting was illustrated in **Figure 7**:

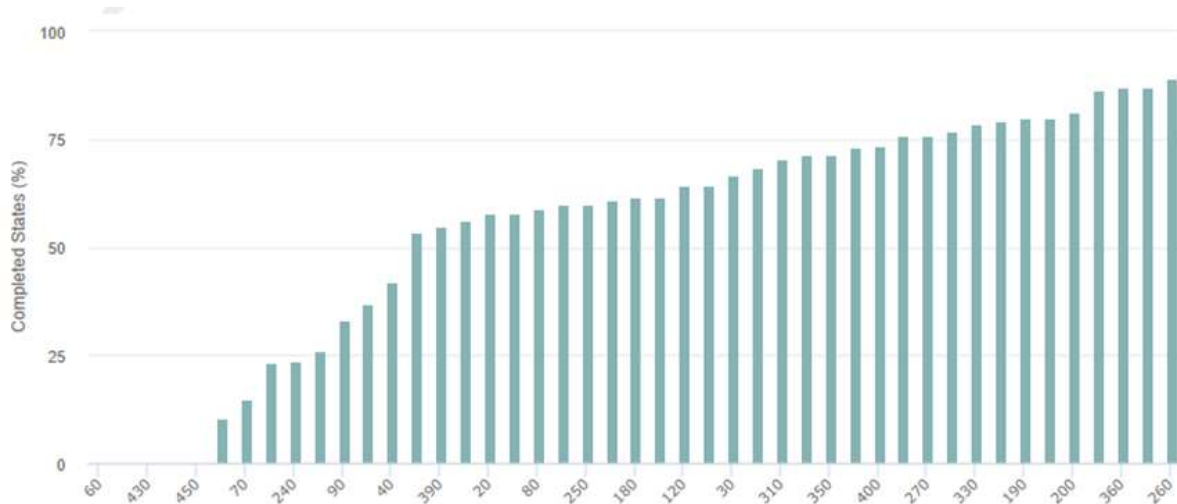


Figure 7: Percentage of Completed Seamless ATM Elements (March 2019)

6.4 The following APANPIRG Conclusions are related to implementation actions that Asia/Pacific States and Administrations should have taken:

APANPIRG 24/55 State Seamless ATM Planning

That, given the urgency and priority of Seamless ATM planning for the Asia/Pacific as acknowledged by the 46th Conference of Directors General of Civil Aviation (DGCA, Osaka, Japan, 12-16 October 2009) and APANPIRG/22 (05-09 September 2011), States should be urged to:

- a) review Version 1.0 of the Asia/Pacific Seamless ATM Plan and utilise the Plan to develop planning for State implementation of applicable Seamless ATM elements;*
- b) ensure relevant decision-makers are briefed on the Seamless ATM Plan;*
- c) submit the first Regional Seamless ATM Reporting Form to the ICAO Regional Office by 01 March 2014; and*
- d) where possible, participate and contribute to Seamless ATM system collaborative training and research initiatives.*

APANPIRG 27/1 Mobilization of Human / Financial Resources to Achieve the Seamless ATM Plan Objectives

That, States/Administrations not achieving the expected implementation progress of regional priorities for Air Navigation Systems, should: a) give highest priority to the implementation of regional priorities and provide human/financial resources to CAAs and ANSPs to complete Seamless ATM phase I implementation; and b) mobilize human and financial resources to plan for timely implementation of phase 2 and phase 3 elements assessed as relevant by their national gap analysis.

6.5 In 2013, the Asia/Pacific Region agreed in endorsing APANPIRG Conclusion 24/55 that it was essential to brief decision-makers and to review the Plan to develop State planning. Three years later, APANPIRG/27 had noted that: *the ten regional targets planned for completion in November 2015 were far from being achieved as of August 2016; the second cycle of the seamless ATM planning is starting and needs focus from high decision makers to mobilize adequate resources.*

6.6 Notwithstanding these APANPIRG Conclusions and associated Action Items (such as Action Item 52/21) from the Conferences of Directors General of Civil Aviation –Asia and Pacific Regions), the lack of adherence to commitments first outlined in the Kansai Statement in 2009 indicated a lack of high-level agreement to modernisation by many States. Therefore, a stronger emphasis on a

whole-of government planning approach to include all stakeholders using a National Air Navigation Plan (NANP) is necessary, to ensure greater buy-in, resource allocation and accountability through monitoring.

x.xx The Asia/Pacific Regional Air Navigation Plan Volume II requires that States shall establish and maintain a NANP that supports implementation of the Global Air Navigation Plan and regional air navigation planning². It further states that States shall report their implementation progress and status of the applicable global and regional air navigation planning elements at least once each year, and provides a list of Basic Planning Elements (BPE) that should be included in the NANP.

x.xx Few States have reported their NANP status, and a NANP reporting template proposed by ICAO in 2021 did not reach consensus agreement due to the objection of one State.

Airspace and FIR Analysis

6.7 During earlier studies, there were several features of the lack of Seamless ANS facilities and practices that had been evident in the Asia/Pacific region.

- a) Size of FIR – fragmented FIRs resulting in flights transiting multiple FIRs with multiple TOC points.
- b) Traffic density – the capacity of ANSP infrastructure and airspace had not kept up with traffic growth.
- c) Airspace and ATS route design and capacity –
 - route structure based on historical requirements and not on current aircraft navigational capability;
 - ground-based navigation aid routes, around which SUAs have grown;
 - crossing tracks with and without ATS surveillance, whereby States mainly rely on the use of FLAS for procedural flight level separation;
 - requirement for vertical transitions because of the two different FLOS (metric and imperial) in the region;
 - routes with flight level, direction, and time restrictions making flight planning more complex;
 - routes with restrictions that are un-coordinated with neighbouring FIRs; and
 - restrictive route structures agreed to in a historical context which is inadequate for today's traffic requirements.
- d) ATS surveillance and communications capability -
 - non- existent/unreliable surveillance or communications capability at times;
 - capability not fully utilised to provide appropriate level of service; and
 - hand-off procedures not aligned to ATM facilities and capabilities.
- e) Compatibility between FIRs –
 - Infrastructure development based only on national requirements, resulting in duplicated and yet uncoordinated facilities; and
 - Unnecessarily conservative separation requirements at TOC points (it was not

² Asia/Pacific Regional Air Navigation Plan Volume II, Section 3. *Specific Regional Requirements*

clear if this is due to lack of confidence in adjacent FIRs capability to adhere to agreed procedures, or for other operational reasons).

f) ATC standards –

- Apparent reluctance in applying ICAO standard separation minima (it was not clear if this is due a lack of confidence in ATM competence or capability); and
- Although GNSS separation is available in Doc 4444, few ANSPs in the Asia/Pacific Region used this as an alternative means of providing longitudinal separation.

g) Focus groups

- Lack of effective focus groups to address airspace capacity and FIR issues, although there had been an increase in informal and bi-lateral ATM coordination;
- Lack of a requirement for regular review mechanisms of operational issues within an FIR, including feedback from aircraft operators.

h) non-universal implementation of AIDC.

6.8 Generally flights operating on Major Traffic Flows (MTFs) between large FIRs (particularly where there were multiple FIRs being provided services by one State) in Category R airspace were already reasonably seamless, such as in the Pacific. However, apart from being largely oceanic in nature, these MTFs had the advantage of being usually in an east/west alignment between continents and were not impacted by busy crossing routes.

6.9 In addition, lower traffic density MTF enabled flexible tracks such as UPR applications. It was notable that these MTFs tended to have dedicated focus groups like Informal South Pacific ATS Coordinating Group (ISPACG) and Informal Pacific ATC Coordinating Group (IPACG) conducting regular reviews of operational efficiency.

6.10 Where long and short haul routes crossed multiple smaller FIRs, particularly with busy regional flows, there was a greater likelihood of reduced efficiency caused by a combination of inconsistent application of ATM procedures and standards, non-harmonized infrastructure development, route structure, TOC and other legacy issues. However, there were also examples of partly Seamless ANS between some busy city pairs (such as Singapore/Kuala Lumpur and Kuala Lumpur/Bangkok) in the region, resulting from bilateral efforts between ANSPs.

6.11 The Pearl River Delta airspace contained very dense air traffic served by Hong Kong, Macau, Shenzhen, and Guangzhou aerodromes, and associated heliports had Airspace Organization and Management (AOM) and Civil-Military coordination issues that stemmed largely from the division of responsibility between FIRs. Segregated SIDs and STARs, application of FUA and holistic ‘Metroplex’ planning principles as well as more integrated ATS systems were needed to achieve greater optimisation of the limited airspace available.

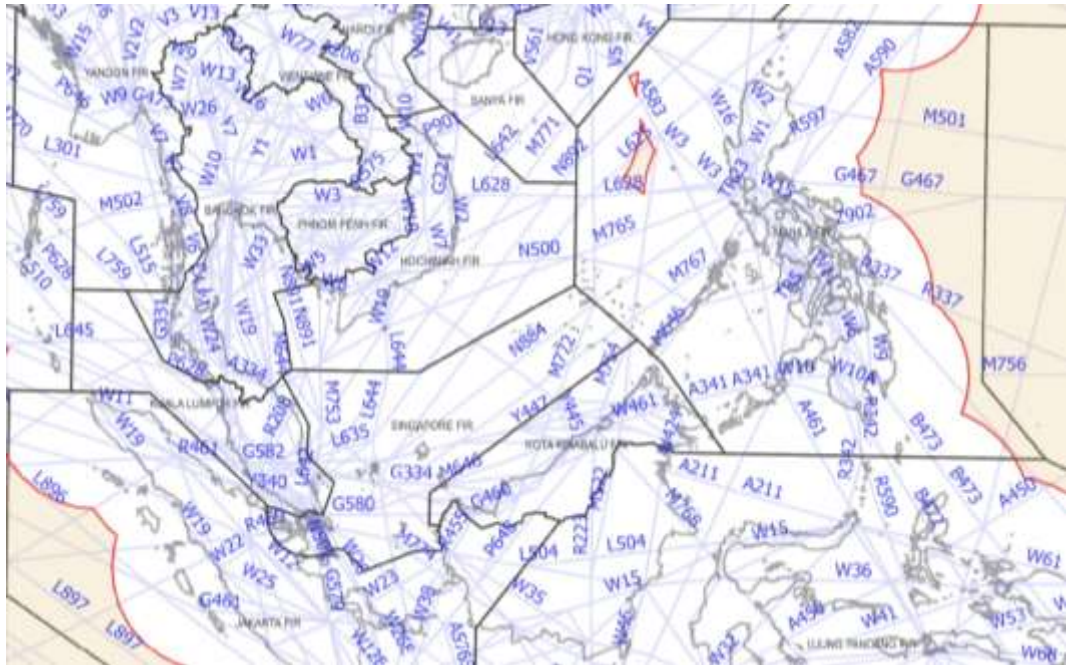


Figure 8: South China Sea ATS surveillance gaps (as at September 2019)

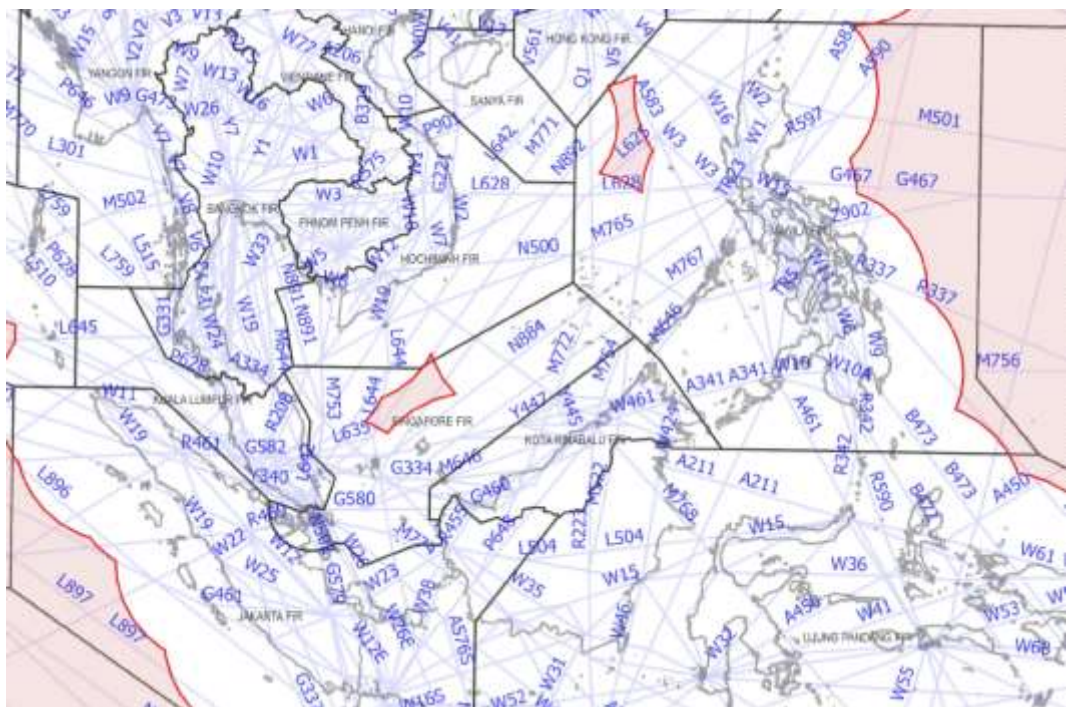


Figure 9: South China Sea ATS DCPC VHF gaps (as at September 2019)

Note: Figure 9 only considers DCPC VHF communications and does not include other forms of DCPC communications.

6.12 **Figure 10** and **Figure 11** provide information on ATS surveillance and communication gaps in the Bay of Bengal (BOB).

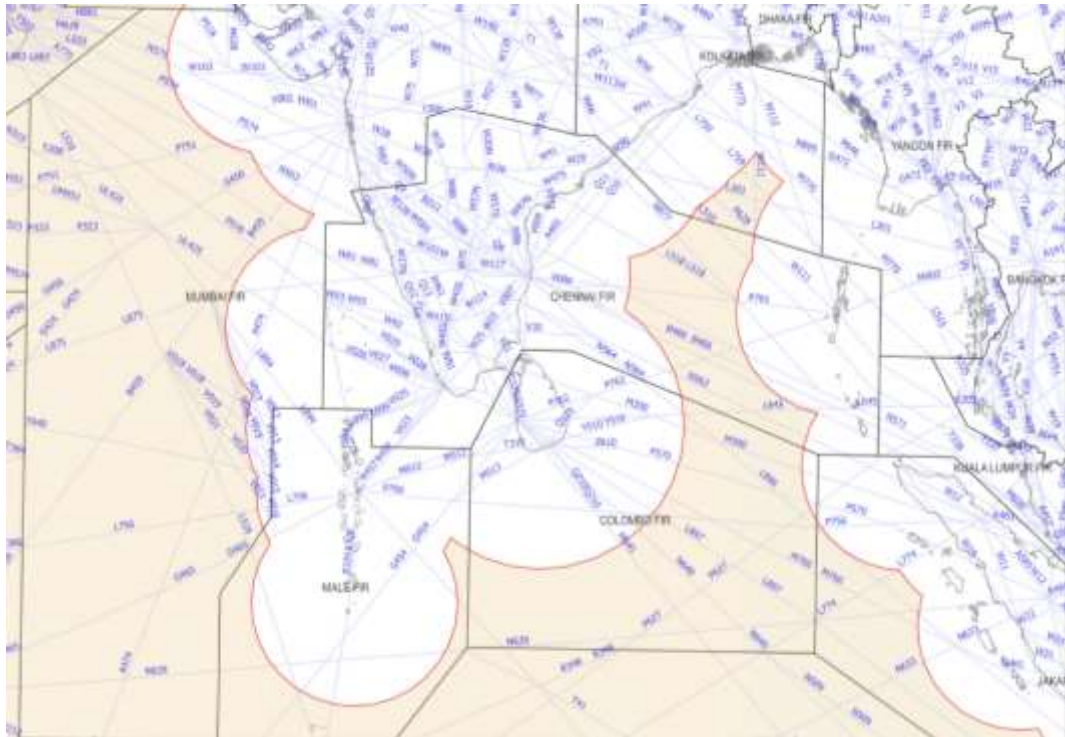


Figure 10: Bay of Bengal ATS surveillance gaps (as at September 2019)

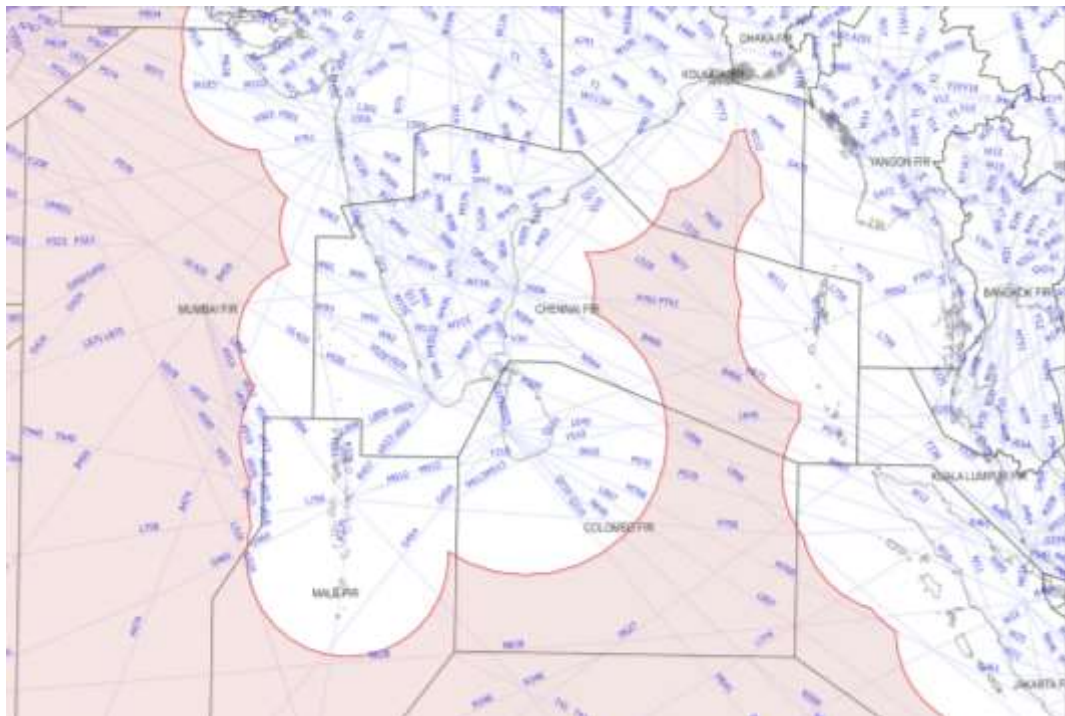


Figure 11: Bay of Bengal ATS DCPC VHF gaps (as at September 2019)

6.13 The main areas of the Asia/Pacific region lacking ATS surveillance and DCPC VHF only communication coverage which need to be rectified with such capability from ground or space-based solutions due to traffic density, weather deviations and contingency responses are as follows:

- a) highest priority: SCS airspace between China, Hong Kong China and the Philippines

(Figure 8 and Figure 9);

- b) high priority: BOB airspace between the Indian subcontinent and the Andaman Islands (**Figure 10 and Figure 11**), the Indian subcontinent and the Arabian Sea;
- c) medium priority: airspace between Indonesia and Australia (between Java and West Australia); and
- d) lower priority: Coral Sea between Papua New Guinea and Australia.

Europe – Asia/Pacific Trans-Regional Issues

6.14 A number of ATS routes from the Russian Federation converged within Mongolian airspace because of the limited number of entry/exit points on the Mongolian/Chinese airspace boundary. Military restrictions had affected ATS route development to China/Mongolia/DPRK and Japanese airspace. An enhancement of Civil-Military cooperation and ATM coordination is necessary to address these trans-regional issues.

6.15 There was a long-standing problem with the incompatibility of some elements of the European On-Line Data Interchange (OLDI) system with the more global AIDC messages from the Russian Federation to China and Mongolia.

6.16 Russia utilised a 30 km (16NM) separation within its upper airspace, while Mongolia initially used 80NM when ATS surveillance was implemented in mid-2012, with an intention to reduce this to a surveillance-based separation after appropriate training.

6.17 Given the need to minimise safety issues such as Large Height Deviations and to improve confidence in order to minimise trans-regional separations, ATS surveillance data-sharing between the Russian Federation and China/Mongolia is necessary in accordance with PASL Phase I, even if only based on ADS-B.

North/South America – Asia/Pacific Trans-Regional Issues

6.18 There were no major trans-regional issues between Asia and North America via the Anchorage Oceanic, Fukuoka and Oakland Oceanic FIR due to the continuing work at the IPACG involving Japan and the United States. The Cross-Polar Working Group (CPWG) also discussed operations extending into the area between Asia and North America. The Fukuoka and Oakland Oceanic FIRs had high-density Category R airspace but is served by an OTS (PACOTS; Pacific Organized Track System). ADS-C, CPDLC and AIDC were fully deployed in the Anchorage Oceanic, Fukuoka and Oakland Oceanic FIRs, and common procedures, including 30NM separation standards based on RNP4, DARP, UPR were applied.

6.19 The Oakland Oceanic FIR and South Pacific utilised technologies consistent with Block 0 and with Conflict Prediction and Resolution (CPAR), AIDC, CPDLC and ADS-C, were able to provide a Seamless ANS service already between Asia/Pacific and North America. This included the provision of UPRs and DARP where operationally possible. These developments had been managed through the ISPACG, and were a model for other oceanic regions in the Asia/Pacific.

6.20 The airspace between the Pacific and South America had very low density traffic. South American States had not yet developed the same Seamless ANS services capability in the trans-regional airspace to support ATM and essential SAR services. However, Chile is an active member of ISPACG.

Middle East/Africa – Asia Trans-Regional Issues

6.21 The transition of traffic from the Muscat FIR to the Mumbai FIR is identified as a contributing factor to the congestion in the Bahrain FIR and causal factor for the delayed departures from airports, particularly in the United Arab Emirates. India had recently reduced horizontal separation on some routes to 50/50NM. In addition, FLAS is also used in Arabian Sea Airspace and applied to low density traffic against the higher density Middle East (MTF AR-5) routes. Owing to the improved utilisation of CPDLC, FLAS is currently being used only on the following five ATS Routes in Mumbai FIR: P751, G450 (non-CPDLC equipped aircraft), P570, N563 and M300.

6.22 Oman required 10 minute longitudinal separation between eastbound aircraft from the United Arab Emirates regardless of the level the aircraft were climbing to, with plans to reduce this to seven minutes, consistent with the 50NM standard applied within the Mumbai FIR. However, this is still very restrictive, given the ATS surveillance coverage within the Muscat FIR and the fact that the aircraft were climbing to a number of different flight levels.

6.23 The problem of OLDI conversions to AIDC between India and the Sultanate of Oman had prevented implementation of AIDC trans-regionally in this area thus far.

ADS-B Collaboration

6.24 Potential projects highlighted in the past include ADS-B data sharing between Myanmar and India over the BOB and among Singapore, Brunei Darussalam and the Philippines in the eastern part of the SCS.

6.25 In May 2015 the ANSPs of India and Myanmar had signed an ADS-B data sharing agreement at the sidelines of the CANSO Asia Pacific Conference in Fukuoka, Japan thus establishing the collaborative framework for ADS-B data sharing involving ADS-B stations in India (Port Blair and Agartala) and ADS-B stations in Myanmar (Coco Island and Sittwe). The objective was to provide end-to-end surveillance for several busy airways over the BOB similar to that accomplished over the SCS. India had also completed an agreement for implementation of Space based ADS-B Data Services for the Oceanic Regions of Indian FIRs and the trials for the same is likely to commence by Jan 2020.

6.26 ADS-B collaboration over the eastern part of the SCS had also been making progress. Singapore had worked closely with the Philippines and Brunei Darussalam to share ADS-B data and VHF communications to plug surveillance gaps on the trunk routes M767 and N884. SB ADS-B was also being considered to fill any remaining gaps. When completed, these airways within the SCS should have complete -surveillance coverage.

Impact of Major Regional and Global Events

x.xx Discussion of COVID-19 pandemic, ATM contingency issues and the conflict in the Ukraine, To be inserted

United States NextGen Economic Benefits

6.27 The Federal Aviation Administration had conducted a business case study for the Next Generation Air Transportation System (NextGen). NextGen is a wide-ranging transformation of the air transportation system, including ATM technologies and procedures; airport infrastructure improvements; and environmental, safety and security related enhancements. It is consistent with the GANP and the ASBU initiative.

6.28 The cost and benefit calculations underlying the business case for NextGen were based on the FAA's 2011 Mid-Term Concept of Operations and the 2012 NextGen Implementation Plan.

Modelling of NextGen benefits and costs was based on various inputs. For basic inputs, the USA used traffic data from 2010, along with traffic and fleet forecasts released in early 2011. Recommended economic values, such as those for passenger value of time, etc., were used from early 2011. Based on these inputs, the FAA's analysis showed that NextGen mid term improvements (until 2020) would generate more than two and a half times in benefits as costs (**Figure 12**).

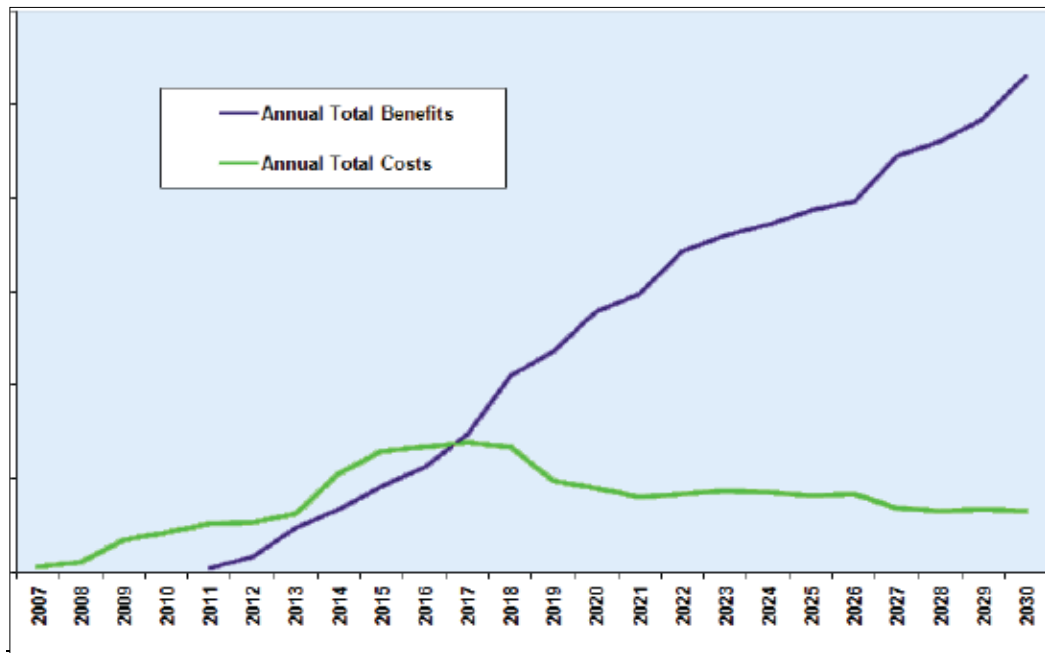


Figure 12: Annual Costs and Benefits

6.29 — Until 2016, NextGen had delivered about \$2.7 billion worth of benefits. This figure is composed of \$900 million in airline direct operating cost savings and nearly \$1.8 billion in passenger time savings. Data from the US aviation system performance concluded that NextGen improvements contribute to more on-time arrivals, fewer and shorter delays, fewer flight cancellations, and less time waiting on the tarmac and in holding patterns

6.30 — The NextGen business case focused on the direct benefits to aircraft operators, passengers, and taxpayers from the rollout of NextGen improvements. Benefits identified in the business case were:

- ADOC;
- PVT;
- Reduced FAA operating costs;
- Additional flights enabled by greater capacity;
- Reduced flight cancellations;
- Increased safety; and
- Environmental benefits from reduced aircraft emissions (CO₂ only).

6.31 — Types of benefits that were **not** included in the business case were:

- New jobs and economic growth associated with major technology initiatives;
- environmental benefits of bio-fuels or improved engine/aircraft technologies; and
- Environmental benefits from reduced aircraft emissions (NO_x or SO₂).

6.32 — The resulting benefit estimates are shown in **Figure 13:**

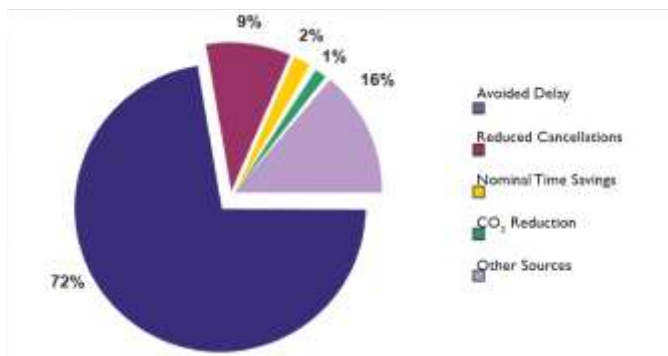


Figure 13: Types of NextGen Benefits until 2030

IATA Seamless ANS Cost Benefit Analysis

6.33 — As general rule, prior to any significant system change, a cost/benefit analysis (CBA) would be conducted to demonstrate the value, negative or positive, of the projected change.

6.34 — A CBA of the transition to an Asia Pacific Seamless ANS environment will be developed when the Seamless ANS Plan has been accepted by APANPIRG on behalf of all Asia Pacific States. Although each State retains responsibility for their sovereign airspace, acceptance of the Seamless ANS Plan by APANPIRG, on behalf of all States, creates an obligation on each State, as far as practicable, to follow the agreed upgrade path.

6.35 — Although a CBA for the region would not be possible due to the complexity of the task, it was felt necessary to demonstrate, at a high level, the benefits of the proposed Seamless ANS Plan.

6.36 — IATA conducted an initial economic analysis which was tabled at APSAPG/3 (Chennai, India, 21-25 January 2013).

6.37 — Today, demand exceeds capacity at many locations and along some MTF. Many Asia Pacific airports have implemented slot management schemes for part of the day when demand exceeds supply. The consequence of this demand-supply gap is that many MTF are subjected to lengthy delays (e.g. BOB) due to capacity limitations.

6.38 — Any system delay causes the costs to increase exponentially. When the demand approaches the capacity limits, aircraft must wait to use the system, or various parts of it, until they can be accommodated. These delays impose costs both in terms of aircraft operating expenses and the value of wasted passengers' time. In addition to the economic and cost benefits, the existing operational environment also causes longer flight trajectory, inefficient airport capacity usage, flight inefficiencies, higher CO₂ emission impacting environment and lower predictability of flight operations.

6.39 — IATA's initial economic analysis indicated that if the States in Asia Pacific do not implement the critical ICAO ASBU elements of the Seamless ANS Draft Plan, aviation's contribution to the Regional GDP will fall from today's **2.2%** to **0.81%** by 2030.

6.40 — Although a 'worst case' scenario this would represent a Regional potential economic benefit **loss** of **US\$16.63 billion per annum** (based on 2012 data), which will reach an accumulated loss of **US\$ 502 billion by 2030**. Upgrading the existing operational environment of ATM is essential in order to enhance the region's economic growth.

6.41 — It was arguable that a lack of investment in aviation infrastructure will result in this

~~investment being diverted to other sectors. However, investment in aviation infrastructure, given the reliance in Asia/Pacific on aviation, will yield a greater benefit than any other transport modality.~~

PERFORMANCE IMPROVEMENT PLAN

7.xx The Asia/Pacific Seamless ANS Plan, Version 3.0 (November 2019) , specified performance objectives to be implemented in three phases of *Preferred Aerodrome/Airspace and Route Specifications* (PARS) and *Preferred ANS Service Levels* (PASL). This version of the Plan, is structured under the following phases:

- Phase II – expected implementation by 07 November 2019;
- Phase III - expected implementation by 03 November 2022; and
- Phase IV – expected implementation by 27 November 2025; and
- Phase V – expected implementation by 23 November 2028.

Note 1: Phase I – elements (expected implementation by November 2015) that had not been completed by November 2019 were moved to Phase II;

Note 2: Phases II and III are retained in this version of the plan due to the delayed availability of the implementation reporting mechanism following the 2019 update, and taking into consideration the impact of the COVID-19 pandemic.

Preferred Aerodrome/Airspace and Route Specifications (PARS)

Note 1: prior to implementation, the applicability of PARS should be verified by analysis of safety, current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet expectations of stakeholders.

Note 2: Phase I had an expected implementation by 12 November 2015.

PARS Phase II (expected implementation by 07 November 2019)

Aerodrome Operations

7.1 All **high density** international aerodromes³ should enable, in accordance with an Airport Master Plan, aerodrome management and coordination services:

- e) when traffic density requires, an appropriate apron management service to regulate aircraft operations in coordination with ATS;
- f) ATS coordination (including meetings and agreements) related to:
 - airport development and maintenance planning;
 - local authority coordination (environmental, noise abatement, and obstacles);

³ High density aerodromes referenced in these performance objectives are:

- aerodromes having 100,000 scheduled movements per annum or more; or
- aerodromes where strategic slot allocation is implemented; or
- aerodromes designated by the relevant authority as requiring or potentially requiring ATFM implementation.

- g) regular airport capacity analysis, ~~which included~~ including a detailed assessment of passenger, airport gate, apron, taxiway and runway capacity.

*Note 1: Sample runway capacity figures are provided from several States in **Appendix D**.*

7.2 Where practicable, all high density international aerodromes should provide, in accordance with an Airport Master Plan, the following facilities to optimise runway capacity:

- h) additional runway(s) with adequate separation between runway centrelines for parallel independent operations;
- i) parallel taxiways, rapid exit taxiways at optimal locations to minimize runway occupancy times and entry/exit taxiways;
- j) rapid exit taxiway indicator lights (distance to go information to the nearest rapid exit taxiway on the runway);
- k) twin parallel taxiways to separate arrivals and departures;
- l) perimeter taxiways to avoid runway crossings;
- m) taxiway centreline lighting systems;
- n) adequate manoeuvring area signage (to expedite aircraft movement);
- o) holding bays;
- p) additional apron space in contact stands for quick turnarounds;
- q) short length or tailored runways to segregate low speed aircraft;
- r) taxi bots or towing systems, preferably controlled by pilots, to ensure efficiency and the optimal fuel loading for departure; and
- s) advanced visual docking guidance systems.

7.3 All high density international aerodromes should operate an A-CDM system for ACIS integrated with the ATM network function consistent with **ACDM-B0/1 – 2** (Priority 1).

Terminal Operations (Category T airspace)

7.4 Where practicable, all aerodromes should have **RNAV 1** (ATS surveillance environment) or **RNP 1** (ATS surveillance and non-ATS surveillance environments) SID/STAR procedures consistent with **APTA-B0/2** (Priority 1).

Note 1: Where a short length or tailored runway designed to segregate low speed aircraft is established, the runway should be served by PBN procedures including SID and STAR that provided segregation from the procedures serving other aerodrome runways as far as practicable.

Note 2: PBN procedures that overlay visual arrival and departure procedures should be established where this provided an operational advantage.

7.5 Where practicable, all instrument runways serving aeroplanes should have the following precision approach systems (or if an APV is not practical, PBN non-precision approaches) consistent with **APTA-B0/1** (Priority 1) and **APTA-B0/3**:

- t) SBAS/GBAS precision approaches; or ILS/MLS approaches (with APV approach as a backup); or
- u) Approaches with Vertical Guidance (APV), either RNP APCH with Barometric Vertical Navigation (Baro-VNAV) or augmented GNSS (e.g. SBAS); or

- v) if an APV is not practical, straight-in RNP APCH with Lateral Navigation (LNAV).

Note: When establishing the implementation of PBN approach procedures in accordance with Assembly Resolution A37-11, States should first conduct an analysis of the instrument runway eligibility for APV approaches. This analysis should include the feasibility of the APV at a particular location, the presence of regular commercial operations and the current or projected user fleet capability for APV. Locations where APV approach were either not feasible or where regular operators could not realise the benefit of APV should implement RNP APCH with LNAV minima instead of APV, to provide the safety benefits of straight-in approach procedures.

7.6 All international aerodromes with rotary wing operations should establish PBN arrival/departure, approach and/or en-route transiting procedures. PBN Helicopter PinS Operations should be established consistent with **APTA-B0/6** where there is an operational benefit (Priority 3).

7.7 SBAS, GBAS, ABAS and MON systems should be established as appropriate to the level and type of aircraft operations and the operating environment consistent with **NAVS-B0/1 - 4**, subject to an assessment of benefits and costs.

Note 1: the application of GNSS and its augmentations such as GBAS Landing System (GLS) is recommended where these systems were economically beneficial.

Note 2: As far as practicable, airspace and instrument flight procedures associated with international aerodromes should not be constrained by international borders and political barriers, and be established only after appropriate consideration of:

- w) environmental efficiencies;
- x) noise abatement and local authority regulations;
- y) adjacent aerodromes;
- z) conflicting instrument flight procedures; and
- aa) affected ATC units or ATM procedures.

7.8 Unless supported by alternative means of ATS surveillance (such as radar, where there are no plans for ADS-B), all Category T airspace supporting international aerodromes should be designated as non-exclusive or exclusive as appropriate ADS-B airspace requiring operation of ADS-B OUT using 1090ES with DO-260/260A and 260B capability to support **ASUR-B0/1**.

Note 1: non-exclusive means that non-ADS-B aircraft may enter the airspace, but may be accorded a lower priority than ADS-B equipped aircraft, except for State aircraft.

Note 2: in areas where ADS-B based separation service was provided, a mandate for the carriage of ADS-B OUT using 1090ES with DO260/60A or 260B is recommended.

Note 3: States should refer to the ADS-B implementation in the ICAO ADS-B Implementation and Guidance Document (AIGD).

7.9 All Category T airspace supporting international aerodromes should require the carriage of an operable mode S transponder within airspace where Mode S radar services are provided to support ASUR-B0/3.

7.10 All Category T airspace supporting international aerodromes should be designated as non-exclusive or exclusive PBN airspace as appropriate to allow operational priority for PBN approved aircraft, except for State aircraft, to facilitate seamless operations and off-track events such as weather deviations to support APTA-B0/1 – 3 and 6.

En-route Operations

7.11 Unless supported by alternative means of ATS surveillance (such as radar, where there are no plans for ADS-B), all Category S upper controlled airspace supporting international aerodromes should be designated as non-exclusive or exclusive as appropriate ADS-B airspace requiring operation of ADS-B OUT using 1090ES with DO-260/260A and 260B capability to support ASUR-B0/1.

7.12 All Category R and S upper controlled airspace should require the carriage of an operable mode S transponder within airspace where Mode S radar services are provided to support ASUR-B0/3.

7.13 All Category R and S upper controlled airspace should be designated as non-exclusive or exclusive PBN airspace as appropriate to allow operational priority for PBN approved aircraft, except for State aircraft, to facilitate seamless operations and off-track events such as weather deviations to support APTA-B0/2.

Note 1: airspace mandates should be harmonised with adjacent airspace and implemented in accordance with guidance provided in this document.

7.14 As far as practicable, all new ATS Routes should be PBN Routes in accordance with the following specifications to support APTA-B0/1 – 8, and APTA-B1/1 – 5:

- Category R airspace – **RNP 4, RNP 10** (RNAV 10) (other acceptable navigation specifications – RNP 2 oceanic); and
- Category S airspace – **RNAV 2 or RNP 2**.

Note 1: ATS routes should be designated with a navigation performance specification commensurate with the CNS/ATM operational environment (within Category S airspace, the PBN specification is not significant to ATC as it is used for track-keeping assurance, not ATC separation). The ATS route navigation performance specification selected should be harmonised and utilise the least stringent requirement needed to support the intended operation. When obstacle clearance or ATC separation requirements demand, a more stringent navigation specification may be selected.

Note 2: RNP 2 is expected to be utilised before Phase 2, when the RNP 2 instrument procedure design, ATC separation standards and operational approval are in place. The Asia/Pacific recognises an equivalency for RNP 2 as being an aircraft approved for RNAV 2, RNP 1 and with GNSS. Prior to the ICAO standard flight plan being updated to recognise RNP 2, States should ensure that aircraft operators with RNP 2 approval file designator 'Z' in field 10 and 'NAV/RNP 2' in field 18 (in addition to designator 'R' to indicate PBN approved).

Note 3: within Category R airspace, transition to RNP 4 or RNP 2 oceanic specifications is recommended at the earliest opportunity. RNP 4 and RNP 2 requires ADS-C and CPDLC, whereas RNP 2 oceanic requires dual independent installations.

Note 4: the Nineteenth Meeting of the Regional Airspace Safety Monitoring and Advisory Group (RASMAG/19, 26 – 30 May 2014) endorsed the application of 8NM spaced RNAV

~~2 ATS routes within Category S airspace by the Republic of Korea, as it had demonstrably met the Target Level of Safety.~~

7.15 All States should use the ICAO Table of Cruising Levels (FLOS) based on feet as contained in Annex 2 Appendix 3a.

Civil-Military Cooperation

7.16 Civil-Military Airspace expectations are as follows:

- bb) SUA should only be established after due consideration of its effect on civil air traffic by the appropriate Airspace Authority to ensure it will be:
- used for the purpose that it is established;
 - used regularly;
 - as small as possible, including any internal buffers, required to contain the activity therein;
 - if applicable, operated in accordance with FUA principles; and
 - activated only when it is being utilised; and
- cc) SUA should be regularly reviewed to ensure the activities that affect the airspace, and size and timing of such activity are accurately reflected by the SUA type, dimensions, activation notice and duration of activation.

Unmanned Aircraft Systems

7.17 States should implement regulations supporting the integration of UAS operations in non-segregated airspace, using a risk-based approach and in accordance with the Asia/Pacific Regional Guidance for the Regulation of UAS guidance provided by the UAS Advisory Group of the Remotely Piloted Aircraft Systems (RPAS) Panel, as a minimum.

Seamless PARS Phase III (expected implementation by 03 November 2022)

Aerodrome Operations

7.18 All high density international aerodromes should operate an A-CDM system integrated with the ATM network, and an AOP and where practicable an APOC consistent with **ACDM-B1/1 – 2**.

Terminal Area Operations

7.19 Terminal Areas serving high density All international aerodromes should implement CCO and CDO operations consistent with **APTA-B0/4 – 5** where practicable, and performance-based aerodrome operating minima-advanced and basic aircraft consistent with **APTA-B0/7 – 8**.

Note: this does not preclude a State considering implementation of CCO/CDO and performance-based aerodrome operating minima at other aerodromes as appropriate.

7.20 Unless excepted by ATC, all aircraft operating within Category S and T controlled airspace should have systems that enable basic airborne situational awareness AIRB and VSA and where applicable, performance-based horizontal minima consistent with **CSEP-B1/1 – 4**.

En-Route Operations

7.21 As far as practicable, all new ATS Routes should be PBN Routes in accordance with the following specifications to support **COMS-B0/1 – 2, COMS-B1/1 – 3, APTA-B0/1 – 8, and APTA-B1/1 – 5:**

- Category R airspace – **RNP 2 Oceanic** (other acceptable navigation specification – **RNP 4**); and
- Category S airspace – **RNAV 2** or **RNP 2**.

PARS Phase IV (expected implementation by 27 November 2025)

Terminal Operations

7.22 ~~All~~ Terminal Areas serving all high density international aerodromes should implement advanced capability PBN SID and STAR procedures and performance-based aerodrome operating minima for advanced aircraft with SVGS consistent with **APTA-B1/1 – 3**.

Note: this does not preclude a State considering implementation of advanced capability PBN SID and STAR procedures and performance-based aerodrome operating minima for advanced aircraft at other aerodromes as appropriate.

7.23 Where there is an operational benefit, all Terminal Areas serving high density international aerodromes should implement Advanced CDO and CCO operations consistent with **APTA-B1/4 – 5**.

7.xx1 Where there is an operational benefit, Terminal Areas serving all high density international aerodromes should implement point merge operations consistent with **RSEQ-B0/3**.

PARS Phase V (expected implementation by 23 November 2028)

Aerodrome Operations

7.xx2 All high density international aerodromes should establish Airport Operations Centres (AOPCs) consistent with **ACDM-B2/2**.

7.xx3 Where there is an operational requirement and benefit, all international aerodromes should implement performance-based aerodrome operating minima consistent with **APTA-B2/4**.

Preferred ANS Service Levels (PASL)

Note: prior to the implementation, the applicability of PASL should be verified by analysis of safety, current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet expectations of stakeholders.

PASL Phase II (expected implementation by 07 November 2019)

ATS Communications

7.24 All ATS sectors providing ATS surveillance in adjacent airspace should have direct speech circuits or digital voice communications, meeting pre-established safety and performance requirements, and where practicable, automated hand-off procedures that allow the TOC of aircraft without the necessity for voice communications, unless an aircraft requires special handling.

Note: this element is applicable to ATC sectors within ATS units and between ATS units providing services in adjacent airspace.

7.25 Where applicable, all ATC Sectors should be supported by VDL Mode O/A and AMHS communication systems consistent with **COMI-B0/3, 7** (Priority 1).

7.26 ATS systems should enable AIDC (version 3 or later), or an alternative process that achieves at least the same level of performance as AIDC, between en-route ATC units and terminal ATC units where transfers of control are conducted consistent with **FICE-B0/1**, unless alternate means of automated communication of ATM system track and flight plan data are employed (Priority 1). As far as practicable, the following AIDC messages types should be implemented:

- Advanced Boundary Information (ABI);
- Coordinate Estimate (EST);
- Acceptance (ACP);
- TOC; and
- Assumption of Control (AOC).

Note: States should note the necessity to utilise Logical Acknowledgement Message processing (LAM) when implementing AIDC (refer to guidance in Chapter XX in PAN ICD).

ATS Surveillance

7.27 ADS-B (using 1090ES), MLAT or radar surveillance systems should be used to provide coverage of all Category S airspace as far as practicable, and Category T airspace supporting international aerodromes, consistent with **ASUR-B0/1 – 2**. Data from ATS surveillance systems should be integrated into operational ATC aircraft situation displays (standalone displays of ATS surveillance data should not be used operationally).

Note 1: ATM systems, including ATS surveillance systems and the performance of those systems, should support the capabilities of PBN navigation specifications and ATC separation standards applicable within the airspace concerned. Guidance on the performance of ATS communication and surveillance systems is available in ICAO Document Doc 10037 (Global Operational Data-link Document)

Note 2: ATC units with ADS-B where Category S and Category T airspace supporting high-density aerodromes may consider utilizing ADS-B for situational awareness and/or separation.

Note 3: ATC units operating within controlled airspace wholly served by Mode S SSR and/or ADS-B surveillance should implement the use of the standard non-discrete Mode A code 1000 for Mode S transponder equipped aircraft to reduce the reliance on assignment of discrete Mode A SSR codes and hence reduce the incidence of code bin exhaustion and duplication of code assignment.

7.28 Subject to appropriate filtering, ATS surveillance data, particularly from ADS-B, should be shared with neighbouring ATC units to support **ASUR-B0/1 – 2**.

7.29 Within Category R airspace, ADS-C surveillance and CPDLC should be enabled to support PBN-based separations, as well as UPR and DARP, consistent with **COMS-B0/1 – 2** and **FRTO-B0/1-4** and **FRTO-B1/1 – 7**.

~~Note: At the 6th Worldwide Air Transport Conference (ATCONF, Montréal, 18-22 March 2013) support was expressed for work to be undertaken on the schemes of economic incentives, 'best equipped or capable, best served' and 'most capable, best served' concepts. The CONOPS states that in each case where any aircraft that does not meet~~

~~specified requirements, it should receive a lower priority, except where prescribed (such as for State aircraft).~~

7.30 Mode S surveillance and the use of Mode S Downlinked Aircraft Parameters (DAPS) should be enabled in all upper level Category S airspace and all Category T airspace servicing high density city pairs consistent with **ASUR-B0/3**. ATM automation system specifications should include the processing and presentation in ATC human-machine interfaces and decision support and alerting tools, the communications, navigation and approach aid indicators received in items 10 and 18 of FPL and ATS messages, where applicable, and the following Mode S or ADS-B downlinked aircraft parameters as a minimum:

- Aircraft Identification;
- Aircraft magnetic heading;
- Aircraft indicated airspeed or Mach Number; and
- Pilot selected altitude.

Note1: DAPS may not be present in downlinked reports from some aircraft ADS-B applications.

Note 2: Downlinking of correct Aircraft Identification (Flight ID) enables automated coupling of ATS surveillance system information with the flight plan, and unambiguous ATC identification of aircraft. States should undertake comprehensive education programs to ensure pilots set the correct Flight ID. Guidance on the correct use of the aircraft identification function is provided in the ADS-B Implementation and Operations Guidance Document, available on the ICAO Asia/Pacific Regional Office website.

7.31 ATS surveillance systems should enable basic conflict detection and conformance monitoring STCA, MTCD, APW, APM and MSAW consistent with **FRTO-B0/4** and **SNET-B0/1 – 4** (Priority 1). Route Adherence Monitoring (RAM) should be utilised when monitoring PBN route separations. Cleared Level Adherence Monitoring (CLAM) should be utilised to monitor RVSM airspace.

Air Traffic Management

Note: ATM system design (including ATS communication and surveillance, ATC separation minimum, aircraft speed control and ATC training) should be planned and implemented to support optimal aerodrome and enroute operations determined by the capacity expectations for the runway(s) and airspace concerned.

7.32 All international aerodromes where ATFM facilities are required should be served by AMAN/DMAN facilities consistent with **RSEQ-B0/1 – 2** (Priority 1).

Note: All AMAN systems should take into account airport gates for runway selection and other aircraft departures from adjacent gates that may affect arriving aircraft.

7.33 Controlled airspace classification should be consistent with Annex 11 Appendix 4 and applied as follows:

- dd) Category R upper controlled airspace– **Class A**; and
- ee) Category S upper controlled airspace– **Class A**, or if there are high level general aviation or military VFR operations: **Class B** or **C**; and
- ff) Category S lower controlled airspace- **Class C, D** or **E** airspace, as determined by safety assessments.

7.34 All ATC units should authorise the use of the horizontal separation minima stated in ICAO Doc 4444 (PANS ATM), or as close to the separation minima as practicable, taking into account such factors as:

- gg) the automation of the ATM system, including automated hand-off between sectors;
- hh) the capability of the ATC communications system;
- ii) the performance of the ATS surveillance system, including data-sharing or overlapping coverage at TOC points; and
- jj) ensuring the competency of air traffic controllers to apply the full tactical capability of ATS surveillance systems.

Note 1: the delivery of ATC services should be based primarily on the CNS/ATM capability. When using Annex 10 compliant ATS surveillance, 5NM (enroute) or 3NM (terminal) surveillance-based separations should be authorised within ATC sectors. At the TOC points in such environments, 5-10NM should be authorised with auto hand-off and surveillance data-sharing or overlapping coverage at the TOC point, and 5-20NM without auto hand-off, as determined by an appropriate safety assessment.

Note 2: the efficacy, continuity and availability of ATM services should be supported by adherence with regional planning and guidance material regarding ATM automation and ATM contingency systems (regarding ATM contingency operations, refer to the Regional ATM Contingency Plan).

7.35 Priority for FLAS level allocations should be given to higher density ATS routes over lower density ATS routes. FLAS should comply with Annex 2, Appendix 3a unless part of an OTS. FLAS other than OTS should only be utilised for safety and efficiency reasons within:

kk) Category R airspace with the agreement of all ANSPs that provide services:

- within the airspace concerned; and
- within adjacent airspace which is affected by the FLAS; or

ll) Category S airspace with the agreement of all ANSPs that provide services:

- where crossing track conflicts occur within 50NM of the FIRB; and
- ATS surveillance coverage does not overlap the FIRB concerned, or ATS surveillance data is not exchanged between the ATC units concerned.

7.36 ATC units should conduct Airspace Planning and enable systems that manage direct and flexible routings where practicable, and the optimal operation of FUA consistent with **FRTO-B0/1 – 4** (Priority 1).

7.37 All ATC Sectors should have a nominal aircraft capacity figure based on a scientific capacity study and safety assessment, to ensure safe and efficient aircraft operations.

~~*Note: A study of the terminal ATC Sector airspace capacity every 15 minutes is provided in Appendix D*~~

7.38 All ACCs operating within FIRs where demand may exceed capacity should implement ATFM incorporating CDM to enhance capacity, using bi-lateral and multi-lateral agreements, initial integration of ASM with ATFM, Collaborative Network Flight Updates, Basic Network Operation Planning and Initial Airport/ATFM slots, A-CDM Network Interface and Dynamic Slot Allocation consistent with **NOPS-B0/1 – 5** (Priority 1).

Note 1: refer to the Asia/Pacific ATFM Framework on Collaborative ATFM for more

details on Network Operations expectations.

Note 2: full FUA is not yet incorporated into the Asia/Pacific ATFM Framework for Collaborative ATFM.

7.39 ATC systems should utilise electronic flight progress strips wherever automation systems allow the capability due to efficiency and transcription error/data mismatch issues.

Air Navigation Services

7.40 ATM systems should be supported by digitally-based AIM systems consistent with **DAIM-B1/1 – 6**, in adherence with ICAO and regional AIM planning and guidance material. ATM systems should be supported by aeronautical information digital data exchange of at a minimum, version AIXM 5.1 (Priority 1).

*Note: Regional AIM policies are contained within the Asia/Pacific **Regional Plan for Collaborative AIM Plan**.*

7.41 Aeronautical meteorological observations, forecast, warning, climatological and historical products (such as aerodrome meteorological forecasts and reports, aerodrome warnings and wind shear warnings) should be disseminated to users consistent with **AMET-B0/1-4**, and in accordance with global and regional guidance material. An agreement between the MET authority and the appropriate ATS authority should be established to ensure the appropriate exchange of meteorological information obtained from aircraft (Priority 1).

7.42 An appropriate enhanced SAR system and systems to support aircraft tracking capability should be established consistent with the provisions of Annex 12 and to support **GADS-B1/1 – 2**, and in accordance with the *Asia/Pacific SAR Plan*.

ANSP Human and Simulator Performance

7.43 The following systems should be established to support human performance in the delivery of a Seamless ANS service. The systems should consider all the elements of the SHEL Model (Software, Hardware, Environment and Liveware – humans), in accordance with the ICAO Human Factors Digest No. 1 and related reference material:

- a) human performance training for all managers of operational air navigation services (such as aerodrome operators, ATC organisations and aeronautical telecommunications), such training to include the importance of:
 - a proactive organisational culture where managers and operational staff are informed and safety is a first priority, using open communications and an effective team management approach;
 - assessment and management of risks by safety review and assessment teams comprising multidisciplinary operational staff and managers which review safety performance and assess significant proposals for change to ATM systems, particularly those related to human capabilities and limitations;
 - human factors in –
 - air safety investigation;
 - system design (ergonomics, human-in-the-loop);
 - effective training (including the improved application of simulators);
 - fatigue management;

- automated safety nets; and
- contingency planning;
- effective safety reporting systems that –
 - are non-punitive, supporting a ‘Just Culture’;
 - promote open reporting to management; and
 - focus on preventive (systemic), not corrective (individual) actions in response to safety concerns, incidents and accidents.
- b) human performance-based training and procedures for operational staff providing ATS, including:
 - the application of tactical, surveillance-based ATC separation;
 - control techniques near minimum ATC separation; and
 - responses to ATM contingency operations, irregular/abnormal operations and safety net alerts.
- mm) human performance-based training and procedures for staff providing operational air navigation services (such as aerodrome staff operating ‘airside’, air traffic controllers and aeronautical telecommunications technicians) regarding the importance of:
 - an effective safety reporting culture; and
 - ‘Just Culture’ (Priority 1).

Note 1: prevention of fatigue systems should be established to support human performance in the delivery of a Seamless ANS service. The systems should be consistent with guidance within ICAO Doc 9966 FRMS – Fatigue Risk Management System.

Note 2: regarding ATM contingency operations, refer to the Regional ATM Contingency Plan.

Civil-Military Cooperation

7.44 Civil-Military ATM expectations are as follows:

- a) a national Civil-Military body should be formed to coordinate strategic civil-military activities (military training should be conducted in locations and/or at times that do not adversely affect civilian operations, particularly those associated with major aerodromes);
- b) formal civil-military liaison should take place for tactical responses by encouraging military participation at civil ATM meetings and within ATC Centres;
- c) integration of civil and military ATM systems using joint procurement, and sharing of ATS surveillance data (especially from ADS-B systems) should be provided as far as practicable;
- d) joint provision of Civil-Military navigation aids and aerodromes;
- e) common training should be conducted between civil and military ATM units in areas of common interest; and
- f) civil and military ATM units should utilize common procedures as far as practicable.

Note: the term ‘military’ in this context may include other State functions such as customs, police, and paramilitary activities.

7.45 All States with organisations that conduct ballistic launch or space re-entry activities should ensure:

- a) the development of written coordination agreements between the State civil aviation authority and the launch/re-entry agency concerned;
- b) that strategic coordination is conducted between the State civil aviation authority and any States affected by the launch/re-entry activity at least 14 days prior to the proposed activity, providing notice of at least:
 - i) three days for the defined launch window; and
 - ii) 24 hours for the actual planned launch timing;
- c) that consideration of affected airspace users and ANSPs is made after consultation, so that the size of the airspace affected is minimized and the launch window is optimized for the least possible disruption to other users ; and
- d) that communication is established with affected ANSPs to provide accurate and timely information on the launch/re-entry activity to manage tactical responses (for example, emergencies and activity completion) (Priority 1).

Note 1: increasingly, ballistic launch and space re-entry activity is being conducted by commercial organisations, so this element applies equally to State or private operations.

Note 2: guidance for States on ballistic launch and space re-entry activity is available on the ICAO Asia/Pacific eDocuments webpage.

PASL Phase III (expected implementation by 03 November 2022)

Aerodrome Operations

7.46 All ATC units providing services to **high density** international aerodromes should operate extended arrival metering consistent with **RSEQ-B1/1**.

7.47 All ATC units providing services to international aerodromes should operate basic ATC surface operations tools, comprehensive situational awareness, situational awareness, alerting service consistent with **SURF-B0/1 – 3**.

7.48 All ATC units providing services to international (ICAO **aerodrome reference** codes⁴ 3 and 4) aerodromes should operate advanced surface traffic management visual aids, pilot comprehensive awareness and runway alerting, enhanced ATC alerting, routing service to support ATC and enhanced vision systems (EVS) for taxiing and runway safety alerting logic consistent with **SURF-B1/1 – 5**.

Note1: AMAN/DMAN arrival/departure management needs to be integrated with advanced surface management systems: A-SMGCS with SMAN or ASDE-X.

Note 2: SURF standards are provided in EUROCAE/RTCA documents ED-159/DO-312/ED-165.

7.49 All ATM systems serving **high density** international aerodromes should implement Data-link Departure Clearance (DCL) compliant with EUROCAE WG78/RTCA SC 214 standards.

Terminal Operations

7.50 ATS surveillance systems should enable Enhanced STCA with aircraft parameters and in

⁴ Annex 14 Aerodromes Volume I Aerodrome Design and Operations section 1.6

complex TMAs consistent with **SNET-B1/1 – 2**.

En-Route Operations

7.51 ACCs should enable, where practicable, Free Route Airspace, RNP routes, Advanced FUA and Airspace Management (ASM), Dynamic Sectorisation, Enhanced Conflict Detection Tools and Conformance Monitoring and Multi-Sector Planner Function consistent with **FRT0-B1/1 – 7**.

Note: CPAR is a key enabler for 'free route airspace' and enroute UPR and DARP operations.

7.52 All ACCs operating within FIRs where demand may exceed capacity should operate systems that enable, where applicable, Short Term ATFM measures, Enhanced NOPS Planning, Enhanced integration of airport operations and NOPS planning, Enhanced Traffic Complexity Management, Full integration of ASM with ATFM, Initial Dynamic Airspace configurations, Enhanced ATFM slot swapping, Extended Arrival Management, ATFM Target Times and Collaborative Trajectory Options Programme consistent with **NOPS-B1/1 – 10** supporting the integration of time-based management within a flow centric approach, consistent with **TBO-B0/1** and **TBO-B1/1**.

7.53 All ATC units should be equipped with or be able to interface with communication systems appropriate to support the service provided, consistent with:

- a) **COMI-B0/1 – 2, 4 – 6** including ACARS, ATN/OSI, VDL Mode 2 Basic, SATCOM Class C Data, and HFDL; and
- b) **COMI-B1/1 – 4**, including VDL Mode 2 Multi-Frequency, SATCOM Class B (SB-S) Voice and Data, ATN/IPS and AeroMACS Ground-Ground; and
- c) **COMS-B0/1 – 2**, including CPDLC (FANS 1/A & ATN B1) for domestic and procedural airspace and ADS-C (FANS 1/A) for procedural airspace; and
- d) **COMS-B1/1 – 3**, including PBCS approved CPDLC (FANS 1/A+), ADS-C and SATVOICE for domestic and procedural airspace.

Note 1: the Asia/Pacific Region has established the CRV (Common aeronautical Virtual private network), in order for ANSPs serving as Inter-regional Backbone Boundary Intermediate Systems to connect to the IP network infrastructure of other regions. Note 2: ANSPs should upgrade their ATS voice communication systems or implement analogue/digital VoIP converters in compliance with the EUROCAE ED-137 standards (interoperability standards for VOIP ATM components).

7.54 ACCs operating within Category R airspace should implement SB ADS-B consistent with **ASUR-B1/1**, subject to an assessment of costs and benefits.

Note: this does not preclude the use of SB ADS-B by other ATC units to augment surveillance capability or to act as a backup.

Air Navigation Services

7.55 ATM systems should be supported by digitally-based NOTAM consistent with **DAIM-B1/7**.

Note: Regional AIM policies are contained within the Asia/Pacific Collaborative AIM Plan.

7.56 All States should ensure that aeronautical meteorological products supported by automated decision systems or aids using IWXXM consistent with **AMET-B1/1 – 4**.

PASL Phase IV (expected implementation by 27 November 2025)

~~NHL~~

Aerodrome Operations

7.xx4 Where there is an operational benefit, Remotely operated Aerodrome Air Traffic Services should be implemented, consistent with **RATS B1/1**.

Air Navigation Services

7.xx5 Capability for providing aeronautical meteorological observations, forecast, warning, climatological and historical products (such as aerodrome meteorological forecasts and reports, aerodrome warnings and wind shear warnings) in support of automated decision processes or aids and performance based requirements, involving meteorological information, meteorological information translation, ATM impact conversion and ATM decision support should be enabled, consistent with **AMET-B1/1-3**.

7.xx6 Meteorological information should be disseminated to users consistent with **AMET-B1/1-4**, and in accordance with global and regional guidance material.

PASL Phase V (expected implementation by 23 November 2028)

ATS Communications

7.xx7 States should establish FF-ICE (Flight and Flow Information for Collaborative Environment) services consistent with FICE-B2/1 -9. In particular, as a minimum, the following FICE services should be established;

- a) Planning Service -FICE-B2/1
- b) Filing Service- FICE-B2/2
- c) Flight Data Request service- FICE-B2/4
- d) Notification Service- FICE-B2/5
- e) Publication Service- FICE-B2/6

7.xx8 All ATC units should be equipped with or be able to interface with communication systems appropriate to support the service provided, consistent with:

- a) **COMI-B2/1 – 3** including Air/Ground ATN/IPS and AeroMACS and Links for non-safety communication; and
- b) **COMS-B2/1 – 3**, including PBCS approved CPDLC, ADS-C and SATVOICE for domestic and procedural airspace.

7.xx9 States should establish SWIM services consistent with **SWIM-B2/1 to B2/5**.

Air Traffic Management

7.xx10 All ATC units providing services to international high density aerodromes should operate enhanced surface guidance for pilots and vehicle drivers, comprehensive situational awareness and conflict alerting service for runway operations consistent with SURF-B2/1 – 3.

7.xx11 All aerodromes where ATFM facilities are required, should be served by an integrated system of arrival and departure management sequences into a single runway or dependent runways

consistent with **RSEQ-B2/1**.

7.xx12 ACCs and terminal airspaces should enable Dynamic Airspace Configurations for different traffic flow or complex situations, Enhanced Conflict Detection Tools and Conformance Monitoring consistent with **FRT0-B2/1 – 2 and NOPS-B2/2**.

7.xx13 ACCs should enable, where practicable, large-scale cross-border Free Route Airspace in coordination with adjacent FIRs, and enhanced conflict resolution tools consistent with **FRT0-B2/3 – 4**.

7.xx14 ACCs should enable, where practicable, ATFM for cross-border Free Route Airspace in coordination with adjacent FIRs, and enhanced conflict resolution tools consistent with **NOPS-B2/6 and FRT0-B2/3 – 4**.

7.xx15 All ACCs operating within FIRs where demand may exceed capacity should operate systems that enable, where applicable, collaborative network operations planning, further integration of airport operations and NOPS planning, multi ATFM slot swapping and airspace user priorities consistent with **NOPS-B2/1-5** supporting the integration of time-based management within a flow centric approach, consistent with **TBO-B0/1 and TBO-B1/1**.

Air Navigation Services

7.xx16 ATM systems should be supported by:

- a. digitally-based AIM systems ~~consistent with DAIM-B2/1 – 5~~, in adherence with ICAO and regional AIM planning and guidance material; and
- b. integrated aeronautical information service in a SWIM environment in support of enhanced operational ground and air decision-making processes for all phases of flight. ~~DAIM-B2/1~~;

consistent with **DAIM-B2/1-5**.

7.x17 Integrated Aeronautical meteorological observations, in support of enhanced ATM and airport decision making process, particularly in the near term should be established consistent with **AMET-B2/1-3**.

7.x18 Integrated meteorological information service in the SWIM environment in support of enhanced operational ground and air decision-making processes, particularly in the planning phase and near-term should be implemented consistent with **AMET-B2/4**.

RESEARCH AND FUTURE DEVELOPMENT POSSIBILITIES

Research and Development

8.1 To develop the tools and systems required to meet foreseeable long-term requirements, there is a need for States to undertake and co-operate on ATM Improvement. This includes major efforts to define concepts, to extend knowledge and invent new solutions to future ATM challenges so these new concepts are selected and applied in an appropriate timely manner. Such efforts could be forged through collaborative partnerships between, States, ANSPs, International Organizations, institutes of higher learning and specialised technical agencies. This concept is consistent with Seamless ANS Principle 36 (*Inter-regional cooperation ('clustering') for the research, development and implementation of ATM projects*).

8.2 The need for concepts beyond current technology and systems ~~had been~~ was reinforced at APANPIRG/23 in 2012. With the end goal of a globally interoperable ATM system in mind, the region will have to consider planning for a long term supporting concept and infrastructure. States should not overlook the need to include the development of future ATM concepts that will ensure the safety and fluidity of air transportation over the next few decades. The following are possible areas that should be considered for future development, in order to continue pursuance of Seamless ANS beyond ASBU Block 0 and Block 1 implementations and global interoperability:

- a. Space-Based ATS Surveillance - The AN-Conf/12 endorsed Recommendation 1/9 regarding space-based ADS-B systems being included in the GANP (~~Appendix B~~); With the availability of space-based ADS-B several APAC States have commenced studies with a view to its implementation to support improved separation, particularly in oceanic (Category R) airspace. Subject to the development by ICAO of standards and procedures for the application of this technology for ATC separation and the necessary supporting communications systems, regional policy and planning development should examine opportunities and develop policies to take advantage of this technology
- b. Sub-Regional ATFM - Inter-linked (data-sharing) ATFM units (which may be virtual offices) should be developed to serve various sub-regions. This concept is consistent with Seamless ANS Principle 8 (*Sub-regional ATFM based on system-wide CDM serving the busiest terminal airspace and MTF*). The Global ATM Operational Concept paragraph 2.4.3 states: *Demand and capacity balancing will be integrated within the ATM system*;
- c. Collaborative Air Navigation Services - This concept is consistent with the following Seamless ANS Principles: 9 (*Cross-border/FIR cooperation for use of aeronautical facilities and airspace, collaborative data sharing, airspace safety assessment and ATM Contingency planning*) and 15 (*Collaboration by ANSPs for evaluation and planning of ATM facilities*). The AN-Conf/12 endorsed Recommendation 5/1, regarding collaboration in airspace organization and routing, which emphasised, *inter alia*, the need to take advantage of improved models for inter-regional coordination and collaboration to achieve seamless air traffic management and more optimum routes through airspace (~~Appendix B~~);
- d. Airspace Optimisation - the CONOPS states: *Where possible the number of FIRs should be minimized particularly along traffic flows. FIRs should not necessarily be based strictly on the boundaries of sovereign territories*. This concept is consistent with and the following Seamless ANS Principles: 12 (*The optimisation of airspace structure through amalgamation and use of technology*) and 16 (*Optimization of ATM facilities*

through amalgamation and the use of technology, including automation, satellite-based systems and remote facilities). The Global ATM Operational Concept paragraph 2.2.2 states: While acknowledging sovereignty, airspace will be organized globally. Homogeneous ATM areas and/or routing areas will be kept to a minimum, and consideration will be given to consolidating adjacent areas;

- e. Consistent Operating Practices and Procedures - this is aligned with Seamless ANS Principle 3 (*Harmonised regional or sub-regional rules and guidelines*) and 4 (*Shared ATM operational standards, procedures, guidance materials through common manuals and templates*); and
- f. Transition Altitude/Layer Harmonisation – this is consistent with AN-Conf/-12 Recommendation 5/1 b).

MILESTONES, TIMELINES, PRIORITIES AND ACTIONS

Milestones

9.1 Section 7 (Performance Improvement Plan) provides milestones and timelines for a number of elements in the PARS and PASL Phase II, III and IV, being effective 07 November 2019, 03 November 2022 and 27 November 2025 respectively. Phase I elements that had not been completed as at 2019 were moved to Phase II.

9.2 It should be noted that States should commence planning for the various elements, such as PBN specifications detailed in the PARS to cover overall ATM operations, taking into account the whole phase of flight. This should be planned from the approval of this Plan, to ensure a smooth transition by the onset of Phase I, and should include consideration of issues such as:

- aircraft equipage and certification;
- safety/operational analysis and assessment;
- cost-effectiveness;
- budgetary issues;
- development of operational procedures; and
- training.

9.3 States should commence planning for PBN specifications detailed in the PARS and other initiatives which have been globally documented, to facilitate a smooth transition by the onset of Phase I. The Regional PBN Plan is expected to transition to a general guideline for implementation during this period, with the prescriptive PBN specifications being incorporated into this Plan.

9.4 Section 8 (Research and Future Development Possibilities) provides, subject to future agreement by concerned parties, possible Seamless ANS improvements beyond 2019 until 2031.

Priorities

9.5 It is a matter for each State to determine priorities in accordance with its own economic, environmental, safety and administrative drivers. Such drivers may include a data driven assessment of their own performance.

Actions

9.6 Noting that the Plan had the status of guidance material in terms of regional policy expectations, this Plan necessitated a number of implementation actions.

9.7 The ICAO Seamless ANS Reporting System supports the implementation of the global and regional items by monitoring progress of States and administrations.

9.8 ~~A non-binding NANP template is provided on the ICAO Asia/Pacific website under 'eDocuments' at <https://www.icao.int/APAC/Pages/new-eDocs.aspx>. States were expected to maintain a NANP to ensure a whole-of-government level of planning. The NANP supports implementation of the Global Air Navigation Plan and regional air navigation planning. The NANP was expected to be accessible to key stakeholders, including ICAO; however, specific details related to national security may be withheld from public release.~~

9.9 ~~The NANP should detail the State's assessment of its requirements and the implementation process for applicable global and regional air navigation planning elements.~~

9.10 ~~States were expected to report their implementation progress and status of the applicable global and regional air navigation planning elements at least once each year (preferably prior to 01 April) to support:~~

- ~~• global and regional plans (including the Seamless Air Traffic Management Plan and the Regional Air Navigation Plan Volume III); and~~
- ~~• specific plans for aerodromes, Aeronautical Information Management, Air Traffic Flow Management, Air Traffic Management contingency and Search and Rescue.~~

9.11 ~~The NANP should include the following Basic Planning Elements:~~

~~Background — a brief introduction aimed at high level decision makers that describes the need for the plan with benefits and costs, including the necessity for global and regional harmonization and interoperability:~~

- ~~a) general (not necessarily quantitative) description of the Plan's benefits;~~
- ~~b) general description of the costs*; and~~
- ~~c) details of how the State Plan connects to the global and regional planning hierarchy.~~

~~**Note 1: this is a matter for the State to determine, and could be in terms of quantitative, qualitative, cost of implementation or cost of not implementing.*~~

~~**Note 2: ICAO do not require details of costs from States, as this is for the State's benefit.*~~

~~Stakeholder Consultation — high level descriptions and statements:~~

- ~~a) of the process used to consult with stakeholders, including the military; and~~
- ~~b) from key stakeholders (such as Heads of CAAs, ANSPs, military organisations, etc.) endorsing the State Plan.~~

~~Analysis — Information on the State's analysis of:~~

- ~~a) all applicable ASBU and regional elements deemed to be applicable, including a statement of the State's priorities* for implementation; and~~
- ~~b) elements that are deemed to be not applicable, and how these were determined.~~

~~**Note: this assessment should be guided by the priorities determined by APANPIRG*~~

~~Planning — descriptions of:~~

- ~~a) the implementation process, such as how the different stakeholders will work together, design systems and provide feedback on implementation; and~~
- ~~b) each applicable global and regional element's implementation managers (those responsible for execution of the implementation) and timelines.~~

~~Progress — details in the State Plan as to the progress of implementation against the planning timelines.~~

~~*Note: this also provides an indication that the Plan is a 'living document' subject to periodic review and update.*~~

9.12 APANPIRG and its contributory bodies such as the ATM Sub-group and the CNS Sub-group are responsible for the oversight of air navigation issues within the Asia/Pacific, so these bodies needed to be made aware of State implementation progress of Seamless ANS initiatives. APANPIRG and its contributory bodies need to manage the implementation of Seamless ANS through the ASBU framework and this Plan.

9.13 Section 6 (Current Situation) provides detailed analysis and major concerns in the region. Some of the non-ICAO sub-regional collaborative frameworks or actions have successfully achieved ATM operational improvements in the past. These forums will continue to be important in Seamless ANS implementation in the future.

9.14 The ICAO Asia and Pacific Regional Office ~~is responsible for taking actions that assisted~~ assists, where necessary, the implementation of Seamless ANS within its accredited States. In addition, the Asia and Pacific Regional Office ~~coordinated~~ coordinates with adjacent ICAO regional offices on an ad hoc basis or at relevant trans-regional meetings.

Appendix A: KANSAI Statement

The Directors General of Civil Aviation (DGCA) of the Asia and Pacific Regions met for the 46th DGCA Conference in Japan, 12-16 October, 2009. Recalling that the 45th Conference had endorsed the Theme Topic for the 46th DGCA Conference as “Seamless Sky: Bringing Together the Asia/Pacific Regions,” Directors General of the Region held a productive discussion focusing on three aspects of the “Seamless Sky,” namely Air Traffic Management (ATM), Air Cargo Security, and Aviation Safety, and agreed to issue this Kansai Statement.

KANSAI STATEMENT

1. — We recognized that as civil aviation develops and globalization progresses, harmonization in civil aviation systems is becoming critically important in the Asia and Pacific Region, which has been characterized by the diversities of the member States. What people expect from harmonization in civil aviation is that aircraft operators will become capable of seamlessly flying between regions, that the whole of the network will be secured at the agreed level, and that transparent and interoperable standards will be set among States and regions. In this regard, “Seamless Sky” is particularly important in the areas of air traffic management, aviation security and aviation safety.

2. — Regarding Air Traffic Management (ATM), we recognized that the ICAO has been leading the development and implementation of the Global Air Traffic Management system with the implementation target of 2025. The Global Air Traffic Management system will be based on the components described in the Global ATM Operational Concept. We also recognized that the United States and Europe have been developing their future air traffic modernization programmes. Taking such global trends of future ATM system into consideration, we recognized the necessity of planning the future ATM system for the Asia and Pacific Region by the active collaboration and participation of the whole of the Region. In this regard, we agreed that APANPIRG be the starting platform to discuss and plan the future ATM system of the Asia and Pacific Region including targets and a time schedule.

3. — Regarding aviation security, we recognized the significance of enhancing air cargo security. Such efforts will enable member States to protect the flow of air cargo, raise security standards and facilitate international trade in the Asia and Pacific Region. To achieve these desired outcomes effectively, member States are encouraged to collaborate with one another and with ICAO towards developing internationally harmonized measures and processes in air cargo security. We agreed that the further sharing of information and best practices should be promoted, and to consider including provisions on air cargo security into Annex 17, taking into account the need to protect the entire cargo supply chain.

4. — Regarding the aviation safety, we acknowledged the ICAO’s leadership in the improvement of aviation safety. We recognized the importance of the member States’ role in ensuring that their air operators establish and maintain the highest standards in safety through the proper implementation of Safety Management System as envisaged under the State Safety Programme. In addition, we recognized the importance of the safety monitoring activities regarding foreign aircraft by the member States in the Region. We agreed to further enhance the cooperation in these efforts and activities in the Region in a harmonized manner.

5. — We are determined to realize the Seamless Sky in the Asia and Pacific Region from this conference onwards. We agreed to make efforts to move forward toward the harmonized aviation in the Asia Pacific Region in cooperation with all the member States and the ICAO Asia Pacific Regional Office.

Appendix B: Relevant 12th Air Navigation Conference Recommendations

1 ~~Recommendation 1/7 Automatic dependent surveillance broadcast~~

~~That States:~~

~~a) recognize the effective use of automatic dependent surveillance broadcast (ADS-B) and associated communication technologies in bridging surveillance gaps and its role in supporting future trajectory-based air traffic management operating concepts, noting that the full potential of ADS-B has yet to be fully realized;~~

~~b) recognize that cooperation between States is key towards improving flight efficiency and enhancing safety involving the use of automatic dependent surveillance broadcast technology.~~

~~That ICAO:~~

~~e) urge States to share automatic dependent surveillance broadcast (ADS-B) data to enhance safety, increase efficiency and achieve seamless surveillance and to work closely together to harmonize their ADS-B plans to optimize benefits.~~

2 ~~Recommendation 1/9 Space-based automatic dependent surveillance broadcast~~

~~That ICAO:~~

~~a) support, subject to validation, the inclusion in the GANP, development and adoption of space-based automatic dependent surveillance broadcast surveillance as a surveillance enabler;~~

~~b) develop Standards and Recommended Practices and guidance material to support space-based automatic dependent surveillance broadcast as appropriate; and~~

~~c) facilitate needed interactions among stakeholders, if necessary, to support this technology.~~

3 ~~Recommendation 2/1 ICAO aviation system block upgrades relating to airport capacity~~

~~That States:~~

~~a) according to their operational needs, implement the aviation system block upgrade modules relating to airport capacity included in Block 0;~~

~~b) endorse the aviation system block upgrade modules relating to airport capacity included in Block 1 and recommended that ICAO use them as the basis of its standards work programme on the subject;~~

~~c) agree in principle to the aviation system block upgrade modules relating to airport capacity included in Blocks 2 and 3 as the strategic direction for this subject.~~

~~4 Recommendation 3/1 ICAO aviation system block upgrades relating to Interoperability and data through globally interoperable system wide information management~~

~~That States:~~

- ~~a) endorse the aviation system block upgrade module relating to interoperability and data through globally interoperable system wide information management included in Block 1, and recommend that ICAO use it as the basis of its work programme on the subject;~~
- ~~b) agree in principle with the aviation system block upgrade module relating to interoperability and data through globally interoperable system wide information management included in Block 2, as the strategic direction for this subject; and~~

~~That ICAO:~~

- ~~c) include, following further development and editorial review, the aviation system block upgrade modules relating to interoperability and data through globally interoperable system wide information management for inclusion in the draft Fourth Edition of the *Global Air Navigation Plan* (Doc 9750, GANP).~~

~~5 Recommendation 4/2 ICAO ASBU relating to ground surveillance using ADS-B/MLAT, air traffic situational awareness, interval management and airborne separation~~

~~That States:~~

- ~~a) according to their operational needs, to implement the aviation system block upgrade modules relating to ground surveillance, improved air traffic situational awareness and improved access to optimum flight levels included in Block 0;~~
- ~~b) endorse the aviation system block upgrade modules relating to interval management included in Block 1 and recommend that ICAO use them as the basis of its work programme on the subject;~~
- ~~c) endorse the aviation system block upgrade modules relating to airborne separation included in Blocks 2 and 3 as the strategic direction for this subject;~~

~~That ICAO:~~

- ~~d) include, following further development and editorial review, the aviation system block upgrade modules relating to airborne separation in the draft Fourth Edition of the *Global Air Navigation Plan*;~~
- ~~e) adopt “airborne separation” concepts involving controllers assigning tasks to flight crews, with controllers able to apply different, risk-based separation minima for properly equipped ADS-B IN aircraft;~~
- ~~f) in the development of provisions, acknowledge the relationship between airborne separation and airborne collision avoidance system;~~
- ~~g) modify aviation system block upgrade (ASBU) Module B2-85 to reflect c) and f); modify ASBU Module B2-101 to reflect f); and~~
- ~~h) review the concept and terminology supporting B2-25 “airborne separation” and amend the module accordingly.~~

6 Recommendation 5/1 Improved operations through enhanced airspace organization and routing

Considering that performance-based navigation (PBN) is one of ICAO's highest air navigation priorities and the potential benefits achievable through creation of additional capacity with PBN:

That States:

- a) implement performance-based navigation in the en-route environment;
- b) fully assess the operational, safety, performance and cost implications of a harmonization of transition altitude and, if the benefits are proven to be appropriate, undertake further action on a national and (sub)-regional basis;
- c) take advantage of improved models for inter-regional coordination and collaboration to achieve seamless air traffic management and more optimum routes through the airspace;
- d) through the planning and implementation regional groups improve their methods of coordination to increase implementation of en-route performance-based navigation in order to achieve more optimum routes through the airspace;

That ICAO:

- e) encourage the planning and implementation regional groups to support the early deployment of performance-based navigation.

7 Recommendation 6/1 Regional performance framework planning methodologies and tools

That States and PIRGs:

- a) develop and maintain regional air navigation plans consistent with the Global Air Navigation Plan;
- b) finalize the alignment of regional air navigation plans with the Fourth Edition of the *Global Air Navigation Plan* by May 2014;
- c) focus on implementing aviation system block upgrade Block 0 Modules on the basis of operational requirements, recognizing that these modules are ready for deployment;
- d) use the electronic regional air navigation plans as the primary tool to assist in the implementation of the agreed regional planning framework for air navigation services and facilities;
- e) consider how the continuous monitoring approach to safety oversight maps to the evaluation of Member States' safety oversight capabilities concerning aviation system block upgrades;
- f) involve regulatory and industry personnel during all stages of planning and implementation of aviation system block upgrade modules;
- g) develop action plans to address the identified impediments to air traffic management modernization as part of aviation system block upgrade planning and implementation activities.

8 Recommendation 6/4 Human performance

That ICAO:

- a) integrate human performance as an essential element for the implementation of ASBU modules for considerations in the planning and design phase of new systems and technologies, as well as at the implementation phase, as part of a safety management approach. This includes a strategy for change management and the clarification of the roles, responsibilities and accountabilities of the aviation professionals involved;
 - b) develop guidance principles, guidance material and provisions, including SARPs as necessary, on ATM personnel training and licensing including instructors and assessors, and on the use of synthetic training devices, with a view to promoting harmonization, and consider leading this effort with the support of States and industry;
 - c) develop guidance material on using field experience and scientific knowledge in human performance approaches through the identification of human-centred operational and regulatory processes to address both current safety priorities and the challenges of future systems and technologies;
 - d) assess the impact of new technologies on competencies of existing aviation personnel, and prioritize and develop competency-based provisions for training and licensing to attain global harmonization;
 - e) establish provisions for fatigue risk management for safety within air traffic services operations;
 - f) develop guidance material on different categories of synthetic training devices and their respective usage;
 - g) provide human performance data, information and examples of operational and regulatory developments to ICAO for the benefit of the global aviation community;
 - h) support all ICAO activities in the human performance field through the contribution of human performance expertise and resources;
 - i) adopt airspace procedures, aircraft systems, and space-based/ground-based systems that take into account human capabilities and limitations and that identify when human intervention is required to maintain optimum safety and efficiency; and
 - j) investigate methods to encourage adequate numbers of high-quality aviation professionals of the future and ensure training programmes are in line with the skills and knowledge necessary to undertake their roles within a changing industry.
-

9 Recommendation 6/12 Prioritization and categorization of block upgrade modules

That States and PIRGs:

- a) continue to take a coordinated approach among air traffic management stakeholders to achieve effective investment into airborne equipment and ground facilities;
- b) take a considerate approach when mandating avionics equipage in its own jurisdiction of air navigation systems provision, taking into account of burdens on operators including foreign registry and the need for consequential regional/global harmonization;

That ICAO:

- a) continue to work on guidance material for the categorization of block upgrade modules for implementation priority and provide guidance as necessary to planning and implementation regional groups and States;
- b) modify the block upgrade module naming and numbering system using, as a basis, the intuitive samples agreed by the Conference; and
- c) identify modules in Block 1 considered to be essential for implementation at a global level in terms of the minimum path to global interoperability and safety with due regard to regional diversity.

Appendix A: Beijing Declaration

To be inserted

Appendix C B: Seamless ANS Principles

People: Cultural and Political Background

1. High-level political support (including development of educational information for decision-makers) to support Seamless ANS initiatives, including military cooperation and AIM.
2. Education and implementation of non-punitive reporting and continuous SMS improvement systems.

Aviation Regulations, Standards and Procedures

3. Harmonised regional or sub-regional rules and guidelines, modelled on the regional application of common regulations incorporated by reference into local legislation.
4. Shared ATM operational standards, procedures, guidance materials through common manuals and templates.
5. The promotion of mutual recognition of ATM qualifications between States.
6. An emphasis on delivery of ATM services based on CNS capability, resulting in flexible, dynamic systems.
7. The use of high-fidelity simulators to train controllers on the optimal application of ATC separations and procedures that support Seamless ANS applications, emergency and contingency responses, testing of software releases, and may serve as a backup ATM platform.

ATM Coordination

8. Sub-regional ATFM based on system-wide CDM serving the busiest terminal airspace and MTF.
9. Cross-border/FIR cooperation for use of aeronautical facilities and airspace, collaborative data sharing, airspace safety assessment and ATM Contingency planning.
10. Encouragement of military participation in civil ATM meetings and in ATS Centres where necessary.

Airspace Organisation

11. Promoting flexible use airspace arrangements and regular review of airspace to ensure it is appropriate in terms of purpose, size, activation and designation.
12. The optimisation of airspace structure through amalgamation and use of technology.

Facilities: Aerodromes

13. To encourage aerodrome operators to actively participate in ATM coordination in respect of Airport CDM development and operational planning, including aerodrome complexity and capacity.
14. Planning and coordination with local authorities and government agencies to take into account environmental issues, obstacles, aerodrome and PBN development.

ATS Units

15. Collaboration by ANSPs for evaluation and planning of ATM facilities.
16. Optimization of ATM facilities through amalgamation and the use of technology, including automation, satellite-based systems and remote facilities.

Navigation Aids

17. The continued rationalisation of terrestrial navigation aids to satellite-based procedures, while retaining a minimum network necessary to maintain safety of aircraft operations.
18. Support for a GNSS-based global PBN approval standard.
19. Regional cooperation for augmentation systems in terms of interoperability and increased service areas, and a GNSS ionospheric monitoring network.

Telecommunication

20. Encouragement of the use of ground-ground ATN/AMHS and diverse satellite communication systems.
21. Enhancement of data-link capabilities (VHF including VDL M2, SATCOM).
22. Where cost beneficial and appropriate, the implementation of:
 - SATVOICE technologies and standards;
 - HF data-link;
 - VSAT networks in support of COM and SUR.
23. The prioritisation of AIDC systems to alleviate ATC coordination issues.

ATS Surveillance

24. The encouragement of ADS-B and/or MLAT implementation to improve ATS surveillance coverage, redundancy and multiple tracking capability.
25. Establishment of ADS-C where radar, ADS-B (including satellite –based ADS-B) and/or MLAT is not possible.
26. Expansion of ATS surveillance data-sharing initiatives.

Technology and Information: Flight Operations

- 27. Implementation of UPR and DARP where practicable.
- 28. Implementation of CDO and CCO where possible.
- 29. The encouragement of appropriate technologies that support Trajectory-Based Operations.

Aeronautical Data

- 30. Early implementation of AIM, including cooperative development of aeronautical databases and SWIM to support interoperable operations.

ATM Systems and Safety Nets

- 31. Application of ground-based safety nets, which includes tactical and strategic conflict probing (such as APW, STCA) and MSAW.
- 32. Support for Inter-facility Flight Data Processing System capability.
- 33. Collaborative development of CDM, ATFM, A/MAN and D/MAN support tools.
- 34. Encouragement of Digital ATIS and VOLMET information systems.
- 35. Encourage sharing of air traffic data between military ATM systems and civil ATM systems.

ATM Modernisation Projects

- 36. Inter-regional cooperation ('clustering') for the research, development and implementation of ATM projects.
- 37. A focus on technologies for earliest deployment and best cost benefits.

Appendix D: Capacity Expectations

1 Capacity metrics will vary considerably, depending upon many factors such as the COM and SUR capabilities, the presence of terrain, physical attributes of aerodromes and weather. Thus the expectations outlined for the following States need to be treated with caution, however they form a useful guide as to the sort of capability being achieved with modern systems and appropriately trained controllers.

2 **Table D1** provides an indication of potential Aerodrome Arrival Rate (AAR) for a single runway, given aircraft ground speeds and aircraft spacing near the runway threshold (source: *Guide for the Application of a Common Methodology to Estimate Airport and ATC Sector Capacity for the SAM Region, Attachment 7: Calculation of the Aerodrome Acceptance Rate used by the FAA*).

Speed	3NM	3.5NM	4NM	4.5NM	5NM	6NM	7NM	8NM	9NM	10NM
140kt	46	40	35	31	28	23	20	17	15	14
130kt	43	37	32	28	26	21	18	16	14	13
120kt	40	34	30	26	24	20	17	15	13	12

Table D1: Potential Runway Arrival Rate

3 ATC capacity calculations needed to take into account the volume of airspace of each sector, which varied considerably by State, and factors such as automation, density of traffic and complexity of routes/airspace. The ICAO *Manual on Collaborative Air Traffic Flow Management* (Doc 9971) contained guidelines for ATC sector capacity assessment. **Table G2** provides simplified ATC sector calculation guidance from Doc 9971.

Average sector flight time (minutes)	Optimum sector capacity value (aircraft)
3 minutes	5 aircraft
4	7
5	8
6	10
7	12
8	13
9	15
10	17
11	18
12 minutes or more	18

Table D2: Simplified ATC Sector Capacity Table (no complexity/automation allowance)

4 Australia, Japan, New Zealand, Singapore, Thailand and the United States provided runway and airspace (ATC Sector) capacity data, to indicate potential capacity figures in varying Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC) circumstances.

Australia

5 Brisbane and Melbourne aerodrome capacity expectations:

- single runway: **48** (24 arrivals—150 seconds between arrivals, 24 departures, VMC);
- single runway: **40** (20 arrivals—180 seconds, 20 departures, IMC).

Japan

6—Aerodrome capacity expectations:

- Narita (dual runways): ~~56-64~~;
- Haneda (4 runways): ~~74~~.

New Zealand

7—Auckland aerodrome capacity expectations:

- single runway: ~~45~~ (VMC);
- single runway: ~~39~~ (IMC circling);
- single runway: ~~37~~ IMC below circling with missed approach protection for jets);
- single runway: ~~32~~ (IMC below circling with missed approach protection)

8—ATC Sector capacity expectations:

- terminal/low level Category T airspace: ~~12~~ aircraft; and
- en route Category S airspace: ~~15~~ aircraft;
- en route Category R airspace: ~~15~~ aircraft.

Singapore

9—Changi aerodrome capacity expectations:

- single runway: ~~30~~ (IMC); and
- two parallel/near parallel runways: ~~72~~ (IMC);
- three parallel/near parallel runways: to be confirmed, possibly 100+ (IMC).

10—ATC Sector capacity expectations:

- terminal/low level Category T airspace: ~~14~~ aircraft; and
- en route Category S airspace (sector dimension of 150NM x 100NM): ~~7~~ aircraft (extrapolated $\sqrt{6.66 \times \text{airspace volume} = 2.58 \times 7 = 18}$).

Thailand

11—Suvarnabhumi aerodrome capacity expectations:

- single runway: ~~34~~ (VMC/IMC).

United States of America

12—**Table D3** provides an indication of optimal aerodrome parallel or near parallel arrival rate runway arrival capacity at selected USA aerodromes. It should be noted that multiple runway combinations or whether runways were used for arrivals, departures, or both yielded a number of permutations from the data.

Aerodrome	Runways	IMC	VMC
ATL	5	104	126
ORD	5	84	112

DFW	5	90	96
ATL	4	92	112
DEN	4	-	114
LAX	4	64	80
ORD	4	-	92
ATL	3	76	96
DEN	3	-	96
IAD	3	72	100
ATL	2	68	82
JFK	2	-	58
SDF	2	40	52
ATL	1	34	42
SDF	1	20	26
SFO	1	25	27

Table D3: Capacity at selected US airports

13 ——— Average aerodrome arrival capacity expectations (range):

- single runway: IMC average ~~26~~ (25-34), VMC average ~~32~~ (26-42);
- two parallel/near parallel runways: IMC ~~55~~ (40-68), VMC ~~64~~ (52-82);
- three parallel/near parallel runways: IMC ~~74~~ (72-76), VMC ~~97~~ (96-100);
- four parallel/near parallel runways: IMC ~~78~~ (64-92), VMC ~~100~~ (80-112);
- five parallel/near parallel runways: IMC ~~92~~ (84-104), VMC ~~111~~ (96-126).

14 ——— ATC Sector capacity expectations:

- terminal/low level Category T airspace: ~~12-18~~ aircraft; and
- en-route Category S airspace: ~~16-20~~ aircraft; and
- en-route Category R airspace: ~~17-24~~ aircraft.

Summary

15 ——— **Table D4** summarises runway and airspace capacity expectations from States, with the greatest capacity achieved in optimum conditions highlighted in bold.

	Parallel or Near Parallel Runway Capacity					ATC Sector Capacity		
	1	2	3	4	5	T	S	R
Australia	40-48							
Japan		56-64		74				
NZ	32-40					12	15	15
Singapore	30	72				14	18	
Thailand	34							
USA	61	95	150	177	211	12-18	16-20	17-24
Doc 9971 Simplified Table Comparison						15	18	18

Table D4: Capacity Expectations Summary

Note: Given the unique operation environment and constraints of individual States, these figures are indicative only and do not represent the same expectation across different States in the region

Appendix E C: List of References

Global and Regional Framework

~~Doc 9673~~ *Asia/Pacific Regional Air Navigation Plan*
Doc 9750 *Global Air Navigation Plan*
Doc 9854 *Global Air Traffic Management Operational Concept*
Doc 10004 *Global Aviation Safety Plan*

Air Navigation Services

Annex 10 *Aeronautical Telecommunications*
Annex 11 *Air Traffic Services* (particularly Chapter 2 [2.1 and 2.30], and Attachment C)
ASBU Document
ASEAN Master Plan on ASEAN Connectivity
Asia/Pacific Air Traffic Flow Management Concept of Operations
Asia/Pacific Air Navigation Concept of Operations
Asia/Pacific Regional Performance-Based Navigation Implementation Plan (V4.0)
Circular 330 Civil-Military Cooperation in Air Traffic Management
Doc 4444 *Procedures for Air Navigation Services Air Traffic Management (PANS ATM)*
Doc 8071 *Manual on Testing of Radio Navigation Aids Volume 2*
Doc 9613 *Performance-based Navigation Manual*
Doc 9882 *Manual on ATM System Requirements*
Doc 9883 *Manual on Global Performance of the Air Navigation System*
Doc 9906 *Quality Assurance Manual for flight Procedure Design Volume 5*
Doc 9971 *Manual on Collaborative Air Traffic Flow Management*
Global Operational Data-link Document
ICAO AN-Conf/12 Yellow Cover Report on Agenda Item 1
Roadmap for the Transition from AIS to AIM

Flight Operations

Annex 6 *Operation of Aircraft*
Doc 8168 *Procedure for Air Navigation Service Aircraft Operations Volume I Flight Procedures*
Doc 8168 *Procedure for Air Navigation Service Aircraft Operations Volume II Flight Procedures*
Doc 9931 *Continuous Descent Operations (CDO) Manual*
Doc 9993 *Continuous Climb Operations (CCO) Manual*

Human Factors

Annex 1 *Personnel Licensing*
Circular 214 *Fundamentals on Human Factors*
Circular 227 *Training of Operational Personnel on Human Factors*
Circular 241 *Human Factors in ATC*
Circular 249 *Human Factors in CNS and ATM Systems*
Circular 318 *Language Testing Criteria for Global Harmonization*
Circular 323 *Guidelines for Aviation English Training Programmes*
Doc 9835 *Manual on the Implementation of ICAO Language Proficiency Requirements*
Doc 9966 *Fatigue Risk Management Systems*
Human Factors Digest No. 1

CNS SG/27
Appendix L to the Report

REPORTING FORM ON AIR NAVIGATION DEFICIENCIES IN THE CNS FIELDS IN THE ASIA/PACIFIC REGION

Identification		Deficiencies			Corrective Action			
Requirement	States/facilities	Description	Date first reported	Remarks	Description	Executing body	Target date for completion	Priority for action
Reliable ground to ground communication as specified in the regional Air Navigation Plan (Doc.9673) Tables CNS II-1; CNS II-2 & CNS II-3	Afghanistan and Pakistan	Unreliability of AFS communication between Afghanistan and Pakistan was brought to the notice of APANPIRG/21. Lack of reliability in the AFS including data communication between Kabul and Karachi and ATS voice communication between Lahore and Kabul was identified.	September 2010	A follow-up COM coordination meeting held in July 2019 discussed way forward	1. Site visits in Pakistan by expert from the VSAT service provider were made in February and March 2016. Remedial recommendations were provided to CAA, Pakistan. Pakistan requested ICAO to provide assistance in establishing VSAT link in 2022. 2. Both Afghanistan and Pakistan agreed to as first step to recover the VSAT connection by upgrading terminals in Lahore and Karachi. Afghanistan will provide assistance and does the Network Configuration settings; 3. A VPN link was established between Karachi and Kabul through UK. Now the VPN link between UK and Kabul is un-serviceable. 4. Both States also agreed to implement CRV as soon as practical to resolve the existing COM deficiencies. Pakistan Civil Aviation Authority has conveyed ICAO its intention to join CRV by December 2022. Pakistan requested ICAO to coordinate with Afghanistan regarding their tentative timeline to join the CRV.	CAA, Afghanistan and CAA, Pakistan	June 2020	A



**INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE**

ATSEP HUMAN FACTORS GUIDANCE MATERIAL

Advanced Edition – August 2023

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AMENDMENTS

The issue of amendments is announced, when an amendment has been agreed by a meeting of the ICAO Asia/Pacific CNS/SG. The space below is provided to keep a record of such amendment.

RECORD OF AMENDMENTS

Amendment Number	Date	Amended by	Comments
0.0			
0.1			

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PREFACE

This publication is the most important deliverable of the Ad-hoc work group being established in April 2021 in response to the conclusion of “Thirty First Meeting of Asia/Pacific Air Navigation Planning and Implementation Regional Work Group (APANPIRG/31)” in December 2020 for the **Preparation of APAC Regional ATSEP Human Factors Guidance Material**. It aims at providing guidance to States, Air Navigation Service Providers, and their key taskforce ‘ATSEP’ on improving the human performance by addressing the key stress factors through effective countermeasures as proposed in the document.

With the extensive series of group discussions and deliberations, the Ad-hoc work group has prepared **Stress Factor Mapping Document (SFMD)** which focuses on grouping of the stress factors listed in IFATSEA study report- “**Factors adding stress and fatigue to ATSEP**” provided in **Appendix R** to the **CNS SG/24 Report** into key issues then mapping those key issues with the suitable countermeasures listed in the IFATSEA study report. This guidance material has been developed based on the SFMD and countermeasures to be taken.

A working team was established to formulate the structure and develop the contents of the guidance material, and IFATSEA has volunteered to take lead on coordinating and consolidating inputs from members of the working team. The team has successfully completed the task of drafting the regional guidance material within the targeted time and has presented the Regional ATSEP human factors guidance material in the “Twenty-Sixth Meeting of Communication, Navigation and Surveillance Sub-group of ICAO (CNS SG/26)” in September 2022 for review and adoption.

This guidance material have the clear description of all the guidelines for the actions to be taken and the self-evaluation checklists for the ATSEP/ANSPs to evaluate themselves. Also, the best practices that can be adopted and the long-term benefits to the ANSPs on addressing the human factors of ATSEP will be discussed in the document. Work group welcomes all ATSEP, ATSEP representatives and ANSPs for interactions and collaborations from all the regions not restricted to APAC region for their valuable feedback and review of the document for further improvement and adoption by the states. Images from IFATSEA are incorporated in this document.

The support from ICAO APAC Office and contributions from the following volunteer State/Administration and industry partner in preparing the guidance material is acknowledged and highly appreciated:

1. Air Traffic Management Bureau (ATMB), China
2. Airports Authority of India
3. Civil Aviation Authority of Singapore
4. Civil Aviation Authority of Thailand (CAAT) and Aeronautical Radio of Thailand LTD.(AEROTHAI)
5. Directorate General of Civil Aviation, Indonesia and Indonesian Aviation Electronics and Electrical Technician Association (IAEETA)
6. Hong Kong Civil Aviation Department, Hong Kong China
7. Japan Civil Aviation Bureau and Koukuu Hoan Shisetsu Shinraisei Center (KSC)
8. Korea Airport Corporation (KAC) and Incheon International Airport Corporation (IIAC)

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CONTENTS

ACRONYMS AND ABBREVIATIONS	xvii
KEYWORDS.....	xix
1. INTRODUCTION.....	5
1.1. Purpose	5
1.2. Background	5
1.3. Concept.....	7
1.3.1. Systems Approach	7
1.3.2. Mutual benefits for ANSP and ATSEP.....	8
1.3.3. Pareto rule.....	8
1.3.4. CANSO Standard of Excellence in Human Performance Management	9
1.3.5. Organizational Resilience	9
1.3.5.1. Preventative control: Defensive and Consistent	9
1.3.5.2. Mindful Action: Defensive and Flexible	10
1.3.5.3. Performance Optimization: Progressive and Consistent	10
1.3.5.4. Adaptive Innovation: Progressive and Flexible.....	11
1.3.6. Mapping of Resilience Levels and Process Maturity Levels	11
1.3.7. Evaluation method	11
1.4. Safety Roles of ATSEP	12
1.4.1. Activities.	15
1.4.1.1. Operational activities.	15
1.4.1.2. Maintenance activities.....	15
1.4.1.3. Installation activities.	15
1.4.2. Unique characteristics of ATSEP working environment.	15
1.5. Outcomes and Endorsements	15
1.6. Arrangements of this document	16
1.7. Document History and Management.....	16
1.8. Copies	16
1.9. Changes to this document	16
1.10. Editing Conventions	17
1.11. ATSEP Human Factors Guidance Material - Request for Change Form.....	17
1.12. Amendment Record.....	17
2. REFERENCE DOCUMENTS.....	19
3. PEOPLE RESOURCING.....	23
3.1. Introduction.....	23
3.2. Benefits to ANSP	23
3.3. Benefits to ATSEP.....	23

3.4.	Actions by ANSP	23
3.5.	Actions by ATSEP	24
3.6.	Most Influential Countermeasures	24
3.7.	Human Factors Issues Addressed	24
3.7.1.	Directly Addressed Factors	24
3.7.2.	Indirectly Addressed Factors	25
3.7.3.	Additional Factors Addressed	26
3.8.	Self-Evaluation Checklist	26
3.8.1.	Self-Evaluation Checklist for ANSP	26
3.8.2.	Self-Evaluation Checklist for ATSEP	27
3.9.	Resilience and Cost Benefits	28
4.	JOB, ROLE AND SKILLS ANALYSIS AND COMPETENCY MODELLING	31
4.1.	Introduction	31
4.2.	Benefits to ANSP	31
4.3.	Benefits to ATSEP	31
4.4.	Actions by ANSP	31
4.5.	Actions by ATSEP	32
4.6.	Most Influential Countermeasures	32
4.7.	Human Factors Issues Addressed	32
4.7.1.	Directly Addressed Factors	32
4.7.2.	Indirectly Addressed Factors	33
4.8.	Self-Evaluation Checklist	34
4.8.1.	Self-Evaluation Checklist for ANSP	34
4.8.2.	Self-Evaluation Checklist for ATSEP	35
4.9.	Resilience and Cost Benefits	36
5.	KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT	39
5.1.	Introduction	39
5.2.	Benefits to ANSP	39
5.3.	Benefits to ATSEP	39
5.4.	Actions by ANSP	40
5.5.	Actions by ATSEP	40
5.6.	Most Influential Countermeasures	41
5.7.	Human Factors Issues Addressed	41
5.7.1.	Directly Addressed Factors	41
5.7.2.	Indirectly Addressed Factors	42
5.8.	Self-Evaluation Checklist	43
5.8.1.	Self-Evaluation Checklist for ANSP	43

5.8.2.	Self-Evaluation Checklist for ATSEP	44
5.9.	Resilience and Cost Benefits	45
5.10.	Other Countermeasures	45
5.11.	Relevant Appendix	45
6.	INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY	49
6.1.	Introduction	49
6.2.	Benefits to ANSP	49
6.3.	Benefits to ATSEP	49
6.4.	Actions by ANSP	49
6.5.	Actions by ATSEP	50
6.6.	Most Influential Countermeasures	50
6.7.	Human Factors Issues Addressed	51
6.7.1.	Directly Addressed Factors	51
6.7.2.	Indirectly Addressed Factors	51
6.8.	Self-evaluation checklist	53
6.8.1.	Self-evaluation checklist for ANSP	53
6.8.2.	Self-evaluation checklist for ATSEP	54
6.9.	Resilience and Cost Benefits	55
6.10.	Other Countermeasures	55
7.	WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD	59
7.1.	Introduction	59
7.2.	Benefits to ANSP	59
7.3.	Benefits to ATSEP	59
7.4.	Actions by ANSP	60
7.5.	Actions by ATSEP	60
7.6.	Most Influential Countermeasures	60
7.7.	Human Factors Issues Addressed	60
7.7.1.	Directly Addressed Factors	60
7.7.2.	Indirectly Addressed Factors	62
7.8.	Self-Evaluation Checklist	63
7.8.1.	Self-Evaluation Checklist For ANSP	63
7.8.2.	Self-Evaluation Checklist for ATSEP	64
7.9.	Resilience And Cost Benefits	65
7.10.	Relevant Appendix	65
8.	MOTIVATION, COMMITMENT, AND ENGAGEMENT	69
8.1.	Introduction	69
8.2.	Benefits to ANSP	69
8.3.	Benefits to ATSEP	69

8.4.	Actions by ANSP	69
8.5.	Actions by ATSEP	70
8.6.	Most Influential Countermeasure	70
8.7.	Human Factors Issues Addressed.....	70
8.7.1.	Collectively Addressed Factors	70
8.8.	Resilience and Cost Benefits.....	71
8.9.	Other Countermeasures	71
9.	BEHAVIOURAL AND ROLE SPECIFIC COMPETENCIES.....	75
9.1.	Introduction	75
9.2.	Benefits to ANSP	75
9.3.	Benefits to ATSEP.....	75
9.4.	Actions by ANSP	75
9.5.	Actions by ATSEP	75
9.6.	Most Influential Countermeasures	75
9.7.	Human Factors Issues Addressed.....	75
9.7.1.	Directly Addressed Factors.....	75
9.7.2.	Indirectly Addressed Factors.....	76
9.8.	Resilience And Cost Benefits	77
9.9.	Other Countermeasures	77
10.	SAFETY CULTURE PROMOTION	81
10.1.	Introduction	81
10.2.	Benefits to ANSP	81
10.3.	Benefits to ATSEP	81
10.4.	Actions by ANSP	81
10.5.	Actions by ATSEP	82
10.6.	Most Influential Countermeasure.....	82
10.7.	Human Factors Issues Addressed	82
10.7.1.	Directly addressed factors.....	82
10.8.	Resilience and Cost Benefits	83
10.9.	Other Countermeasures	83
APPENDIX 1	STRESS FACTOR MAPPING.....	85
1.1.	Introduction.....	85
1.2.	Description.....	89
APPENDIX 2	STRESS FACTORS	91
2.1.	Introduction.....	91
2.1.1.	Table 1 – Lack of Knowledge, Skills, and Competency.	91
2.1.2.	Table 2 – Lack of proper workload distribution.	92
2.1.3.	Table 3 – Lack of proper procedures, information, tools, and practices.....	93

2.1.4.	Table 4 – Duty duration, cycles of shifts and extended work hours.	94
2.1.5.	Table 5 – Continued stress, fatigue, and pressure.	95
2.1.6.	Table 6 – Lack of knowledge sharing, leadership, and teamwork.	96
2.1.7.	Table 7 – Human Resource Management policies.	97
2.1.8.	Table 8 – Lack of workplace facilities and environment.	98
2.1.9.	Most Significant Factors as per ATSEP	99
APPENDIX 3	COUNTERMEASURES	101
3.1.	Introduction	101
APPENDIX 4	ATSEP DUTY TIME LIMITATION	103
4.1.	Introduction	103
4.2.	Definitions	103
4.3.	Background	103
4.4.	Best Shift duty pattern	105
4.5.	Guidelines for best shift duty pattern	108
4.5.1.	Guideline 1 - Successive night shifts	108
4.5.2.	Guideline 2 - Rest period between night shifts	109
4.5.3.	Guideline 3 - Coherent blocked free time at the weekends	109
4.5.4.	Guideline 4 - Number of free days	109
4.5.5.	Guideline 5 - Shift rotation pattern	111
4.5.6.	Guideline 6 - Early shift	111
4.5.7.	Guideline 7 - Night shift length	111
4.5.8.	Guideline 8 - Concentration of working hours restriction	111
4.5.9.	Guideline 9 - Notification of rosters	112
4.5.10.	Guideline 10 - Rest in Night Shift / Single Shift	112
4.5.11.	Guideline 11 - Emergency Duty	112
4.6.	References	112
APPENDIX 5	MEASURES DURING PANDEMIC	113
5.1.	Introduction	113
5.2.	Backdrop of the Paranoia: Fear psychosis behind Covid- 19.....	113
5.3.	The Mitigation measures to be taken during Pandemic.....	114
5.4.	The future course of Action.....	114
5.5.	References.....	115
APPENDIX 6	PROGRESSIVE TRAINING	117
6.1.	Introduction	117
6.2.	Background of ATSEP training	117
6.3.	The Roadblocks to complete adoption of the Docs 9868 & Doc 10057	119
6.4.	How can these roadblocks be addressed	119

6.5. References.....	119
APPENDIX 7 STRESS MANAGEMENT	121
7.1. Introduction.....	121
7.1.1. Process of stress – Three stages	121
7.1.1.1. Alarm reaction	121
7.1.1.2. Resistance stage	121
7.1.1.3. Exhaustion stage	121
7.1.2. Causes of stress at working situations	122
7.1.2.1. Stressors in the working environment	122
7.1.3. Consequences of stress.....	122
7.1.4. Symptoms of Stress.....	123
7.2. Stress Management	123
7.2.1. Human Nature and Individual Differences	123
7.2.1.1. Human Nature	124
7.2.1.1.1. Biological Models	124
7.2.1.1.2. Goal-based models	124
7.2.1.2. Individual Differences	125
7.2.1.2.1. Extraversion	125
7.2.1.2.2. Neuroticism.....	125
7.2.1.2.3. Agreeableness	125
7.2.1.2.4. Conscientiousness.....	125
7.2.1.2.5. Openness to experience	125
7.2.2. Relations Between Personality and Coping	125
7.2.3. Benefits of active stress management	126
7.2.4. Steps involved in the minimization of the stress	126
7.2.4.1. Identify the sources of stress in your life	126
7.2.4.2. Address the unhealthy coping strategies	126
7.2.4.3. Managing predictable stressors.....	126
7.2.4.3.1. Avoid unnecessary stress.....	127
7.2.4.3.2. Alter the situation	127
7.2.4.3.3. Adapt the stressor	127
7.2.4.3.4. Accept the things you cannot change.....	127
7.2.4.4. Manage time and schedules.....	127
7.2.5. Assistance under stressful situation	127
7.2.6. Effects of shocking and stressful situation	128
7.3. References.....	128

APPENDIX 8 SAFETY CULTURE	129
8.1. Introduction	129
8.1.1. Safety Importance in Aviation	129
8.1.2. Safety: The Foremost Strategic Objective of ICAO	129
8.1.3. Safety Work Culture	129
8.1.4. Safety Culture and Safety Performance	130
8.1.4.1. Quality safety culture entails considerate safety behaviour	130
8.1.4.2. ATSEP perform even when not under safety supervision	130
8.2. Safety Culture Development and Benefits	131
8.2.1. Developing A Positive Safety Culture	131
8.2.2. Safety Culture as Safety Enabler of Safety Management	131
8.2.3. Safety Work Culture benefits	131
8.2.3.1. Safety work culture benefits in case of adoption in ATSEP domain	132
8.2.4. Benefits of Safety Management	132
8.2.5. Safety Culture Enablers and Disablers	133
8.3. Safety Reporting and Just Culture	136
8.3.1. Safety Culture and its influence on Safety Reporting	136
8.3.2. Safety Reporting	136
8.3.2.1. Significance of Safety Reporting	136
8.3.2.2. Dos and don'ts	137
8.3.3. Just Culture	138
8.3.3.1. Definition	138
8.3.3.2. Just Culture conception	138
8.3.3.3. Just Culture misconception	138
8.3.4. Safety Culture and Cultural Diversity	138
8.4. Challenges and Addressing the Roadblocks	139
8.4.1. Loss of Upper Management Support	139
8.4.2. Lack of Safety Accountability	139
8.4.3. Lack of leadership commitment	139
8.4.4. Lack of resources for safety success	140
8.4.5. Ageing workforce	140
8.4.6. Rise in the recruitment of young and less experienced ATSEP	140
8.4.7. Loss of safety-related data	140
8.4.8. Safety Feedback problems	141
8.4.9. Safety culture and organizational change	141
8.4.10. Economic unpredictability	141

8.5. Monitoring and Measuring Safety Culture Effectiveness	141
8.5.1. Safety Culture Assessment	141
8.6. References	142
APPENDIX-9: SELF EVALUATION CHECK LISTS	143
COMPENDIUM	153

LIST OF FIGURES

Figure 1: Timeline of ATSEP Human Factors Guidance Material	6
Figure 2: Interlinked Stress Factors and Human Performance	7
Figure 3: Typical Working Environment of ATSEP	13
Figure 4: Aviation Capsule	14
Figure 5: ATSEP Duty Time Analysis - 1	104
Figure 6: ATSEP Duty Time Analysis - 2	104
Figure 7: ATSEP Duty Time Analysis - 3	105
Figure 8: Sleep / Wake Cycle	105
Figure 9: Shift Duties Effect on Health	106
Figure 10: Shift work with ATSEP Performance and Safety	110
Figure 11: Scope of ATSEP activities	117
Figure 12: ATSEP training phases	118
Figure 13: ATSEP training progression	118
Figure 14: Quantifying Safety Behaviour	130
Figure 15: Benefits of Safety Management	132
Figure 16: Understanding the evaluation check list process	143
Figure 17: Compendium Picture 1	153
Figure 18: Compendium Picture 2	154
Figure 19: Compendium Picture 3	154
Figure 20: Compendium Picture 4	154

LIST OF TABLES

Table 1: Mapping of Resilience Levels and Process Maturity Levels.....	11
Table 2: ATSEP Human Factors Guidance Material - RFC Form.....	17
Table 3: Reference Documents	19
Table 4: Consequences of Stress.....	122
Table 5: Symptoms of Stress	123
Table 6: Signs of Critical Incident Stress	128

ACRONYMS AND ABBREVIATIONS

ACC	Area Control Centre
AEROTHAI	Aeronautical Radio of Thailand Ltd.
AME	Aircraft Maintenance Engineer
ANSP	Air Navigation Service Provider
APAC	Asia Pacific Region
APANPIRG	Asia Pacific Air Navigation Planning and Implementation Regional Group
APP	Approach Control
ASBU	Aviation System Block Upgrades
ASO	Aeronautical Station Operator
ATC	Air Traffic Controller
ATCO	Air Traffic Control Officer
ATMB	Air Traffic Management Bureau
ATS	Air Traffic Services
ATSEP	Air Traffic Safety Electronics Personnel
BMC	Bone Marrow Cells
CAAT	Civil Aviation Authority of Thailand
CANSO	Civil Air Navigation Services Organization
CBTA	Competency Based Training and Assessment
CM	Corrective Maintenance
CNS	Central Nervous System
CNS/ATM	Communication, Navigation and Surveillance /Air Traffic Management
CNS SG	Communication, Navigation and Surveillance Sub-Group
EST	Eastern Time Zone
EU	European Union
FIR	Flight Information Region
FOCA	Federal Office of Civil Aviation
FPL	Flight Plan
HMI	Human-Machine Interface
HR	Human Resources
HRM	Human Resource Management
IAEETA	Indonesian Aviation Electronics and Electrical Technician Association
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers' Association
IFATSEA	International Federation of Air Traffic Safety Electronics Association
IIAC	Incheon International Airport Corporation
ILS	Instrument Landing System
KAC	Korea Airport Corporation
KM	Knowledge Management
KS	Knowledge and Skill
KSA	Knowledge, Skill, and Attitude
KSC	Knowledge, Skill, and Competency
KSC	Koukuu Hoan Shisetsu Shinraisei Center
L1	Lowest One
L&D	Learning and Development
MET	Metrological Service
NOTAM	Notice to Airmen
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Communication

OIC	Station-In-Charge
PANS- TRG	Procedures for Air Navigation Services-Training
PBN	Performance Based Navigation
PM	Preventative Maintenance
PPE	Personal Protective Equipment
QR	Qualitative Requirements
RADAR	Radio Detection and Ranging
RFC	Request for Change Form
RWY	Runway
SCN	Suprachiasmatic Nucleus
SFMD	Stress Factor Mapping Document
SMS	Safety Management System
SOP	Standard Operating Procedure
SSO	Shift Supervisory Officer
SSP	State Safety Plan
STSB	Swiss Transportation Safety Investigation Board
SWIM	System Wide Information Management
TM	Talent Management
UIC	Unit-In-Charge
UPS	Uninterruptible Power Supply
VHF	Very High Frequency
VVIP	Very Very Important Person
WSO	Watch Supervisory Officer

KEYWORDS

Approach and Avoidance Systems	This is a psychological construct that represents the conflict in motivation to move forward or to move away from an undesired result.
Behavioural and Functional Competencies	Behavioural requirements are specifications of user interactions with a system often represented as use cases. Functional requirements are business specifications such as calculations, business rules and process flow.
Circadian Rhythm	These are 24-hour cycles that are part of the body's internal clock, running in the background to carry out essential functions and processes.
Competency Modelling	Competency modelling is a systematic approach used in human resource management to identify and define the key competencies required for successful performance in specific roles within an organization. Competencies are a set of knowledge, skills, abilities (KSA) combined with behaviour, and other personal attributes that individuals need to effectively carry out their job responsibilities.
Computer-based Maintenance Data Analysis	Computer-based maintenance data analysis refers to the process of using computer systems and software to analyze and draw interpretation from maintenance data collected from various sources. It is a valuable tool for maintenance professionals to make informed decisions and optimize maintenance practices. It leads from reactive to proactive maintenance approach.
DIRTY DOZEN Model	The Dirty Dozen refers to twelve of the most common human error preconditions, or conditions that can act as precursors, to accidents or incidents. These twelve elements influence people to make mistakes. It covers the following dozen factors: 1.Fatigue 2.Stress 3.Complacency 4.Communication 5.Awareness 6.Distracted 7.Lack of knowledge 8.Teamwork 9.Lack of resources 10.Pressure 11.Lack of assertiveness 12.Norms
Double Bind Situation	A situation where opposing interests of safety and judiciary must be served and satisfied.
Extraversion	Extraversion has different emphases in different measures. Sometimes it is based in assertiveness, sometimes in spontaneity and energy. Sometimes it is based in dominance, confidence, and agency, sometimes in a tendency toward happiness.
Human Performance Management	As an ongoing process of identifying, measuring, assessing, and developing the performance of the employees in the organization.
Just Culture	A Culture where front-line operators or other personnel are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated.

Key Performance Indicators	Key Performance Indicators (KPIs) are the critical (key) indicators of progress toward an intended result. KPIs provides a focus for strategic and operational improvement, create an analytical basis for decision making and help focus attention on what matters most.
Maintenance Philosophies	It is the mix of strategies that ensure an item works as expected when needed.
Neuroticism	Concerns the ease and frequency with which a person becomes upset and distressed. Moodiness, anxiety, and depression reflect higher neuroticism
Organization Resilience	Refers to an organization's response to damage and it highlights the ability to recover and grow under uncertainty, crisis, and emergency. This includes following resilience levels – 1.Preventative control: defensive and consistent 2.Mindful action: defensive and flexible 3.Performance optimization: progressive and consistent 4.Adaptive innovation: progressive and flexible
Pareto Rule	The Pareto principle (also known as the 80/20 rule) is a phenomenon that states that roughly 80% of outcomes come from 20% of causes.
PEAR Model	The mnemonic PEAR is used to recall the four considerations for assessing and mitigating human factors in aviation maintenance: 1. People who do the job. 2. Environment in which they work. 3. Actions they perform; and 4. Resources necessary to complete the job.
Process Maturity Levels	Process maturity levels are different maturity states of a process/activity. The processes at higher levels also address the features of the lower levels.
Progressive Training	It defines the ATSEP training requirements in the event of Change within the system; Change of domain; Change of activities, and inclusion of any additional system
Psychological Contract	The term psychological contract refers to the often-unspoken set of expectations and assumptions that two parties (employees and the organisation, its leaders, and managers) have of each other about things like how they will behave and act.
Quality Management	Quality management ensures that an organization, product, or service consistently functions well. It has four main components: quality planning, quality assurance, quality control and quality improvement. Quality management is focused not only on product and service quality, but also on the means to achieve it.
Random Fault Simulation	A technique generally used in the field of electronics and digital systems design and testing to evaluate the performance and reliability of a circuit under fault conditions. In this method, faults are randomly introduced into the system, and the response is analysed to assess its behaviour. This type of test helps to ensure a robust response system.
REASON's Model	Classifies factors contributing to accidents into three domains: Organisational/systems, local workplace, and unsafe acts. The model promotes a focus on the conditions or situation in which the person is trying to perform, conditions which might be designed to create an incident or error.

Role Profile	It focuses on the following aspects of the ATSEP role: key result areas; knowledge, skills and abilities required; behavioural competencies
Safety and Service Strategy	An approach adopted by organizations to optimize a balance between the safety of their stakeholders and the quality of service being provided. It involves implementing measures and policies to ensure a safe environment and minimize risks while also delivering excellent and reliable services to meet customer needs and expectations.
Safety Management System	A systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures.
Safety Performance Indicator	A data-based safety parameter used for monitoring and assessing safety performance.
Scientific Knowledge Management	A systematic process of acquiring, organizing, validating, and disseminating scientific knowledge about human behaviour and capabilities. It involves conducting research and experiments to understand human interactions with systems, products, and environments. This knowledge is organized and stored for easy access, peer-reviewed for accuracy, and integrated into design and development processes to enhance efficiency, safety, and user satisfaction while minimizing errors and accidents.
Scientific Performance Evaluation System	Scientific performance evaluation refers to the systematic and objective process of assessing an individual's or a team's performance in a scientific or research-oriented setting. This evaluation is typically carried out using data-driven methods, standardized metrics, and well-defined criteria to measure and quantify the quality and impact of contributions
Shell Model	The SHELL Model is a conceptual tool used to analyse the interaction of multiple system components. The SHELL Model contains the following four components: a) Software (S) (procedures, training, support, etc.). b) Hardware (H) (machines and equipment). c) Environment (E) (the working environment in which the rest of the L-H-S system must function); and d) Liveware (L) (humans in the workplace).
State Safety Programme	An integrated set of regulations and activities aimed at improving safety.
Strategic People Resourcing	Strategic resourcing is a key part of strategic human resource management that aims on ensuring that organization has the people it needs to achieve the business goals. It is fundamentally related with matching human resources to the strategic and operational requirements of the organization and ensuring the full utilization of these resources.
Systems Approach	Systems approach is a management perspective which advocates that any business problem should be seen as system which is made up of a hierarchy of interrelated and interdependent sub-systems. Each part of the system derives inputs and information from other system to achieve the business goal. The system changes as per the environment and reacts to the changes in the environment. All departments and sub-systems of the overall large system need to product results.

System Wide Information Management	A global Air Traffic Management (ATM) industry initiative to harmonize the exchange of Aeronautical, Weather and Flight information for all Airspace Users and Stakeholders. SWIM is an integral part of the International Civil Aviation Organization (ICAO) Global Air Navigation Plan (GANP)
Talent Management	Talent management is the strategic process of attracting, developing, and retaining skilled individuals within an organization. It involves identifying, nurturing high performing individuals, and aligning their abilities with the Organization mission and vision. Talent management encompasses various practices and activities aimed at optimizing human resources and maximizing their contributions to the organization's success.
Workforce Planning	This process identifies anticipated changes to the scope and nature of the organization's activities.

ATSEP HUMAN FACTORS GUIDANCE MATERIAL



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ATSEP HUMAN FACTORS GUIDANCE MATERIAL

To cope with the new technologies and safety levels, Air navigation service providers (ANSPs) need to match modernization plans with human performance management of their key workforce i.e. ATSEP. To ensure the required level of human performance to assure safety, it is essential to understand the factors adding stress and fatigue in the present scenario.

THE OBJECTIVE

This guidance material introduces an important human performance management approach that may effectively address the variables by achieving various levels of maturity. Additionally provides the ANSP with self-evaluation tools to gauge the process maturity levels.

This guidance material focuses on

- The human factors that cause stress, fatigue, and have an impact on job performance
- Key human resource management processes
- Resilience and cost benefits that can be achieved through the process improvisation.

“Because ICAO SARPs drive states regulatory requirements, Human Performance (HP) considerations are essential to the development of those SARPs and their supporting guidance material.

DOC 10151 -MANUAL ON HUMAN PERFORMANCE”

1. INTRODUCTION

1.1. Purpose

To cope with the new technologies and safety levels, Air navigation service providers (ANSPs) need to match modernization plans with human performance management of their key workforce i.e., ATSEP. To ensure the required level of human performance to assure safety, it is essential to understand the factors adding stress and fatigue in the present scenario.

On understanding the factors and their effective countermeasures, ANSPs can plan a human performance management system that can assure continued performance improvement w.r.t ATSEP.

The purpose of this guidance material is to list the factors that add stress, fatigue, and affect their job performance in their working environment (roles, responsibilities, deployment, duty pattern, requirement of knowledge, skills, attitude, competency, training, and resources) and address the factors through process improvement of human performance management system.

This guidance material introduces an important human performance management approach that may effectively address the variables by achieving various levels of maturity. Additionally provides the ANSP with self-evaluation tools to gauge the process' maturity levels.

After the COVID-19 pandemic, it is important to get the organisation ready for higher levels of resilience so that it can recover and move forward. The advice material also makes a correlation between resilience levels and the maturity levels of the human performance management process.

Ergo, this guidance material focuses on

- the human factors that cause stress, fatigue, and have an impact on job performance.
- key human resource management processes that address them
- resilience and cost benefits that can be achieved through those process improvisation.

1.2. Background

Initially at the global level, the human factors issues were significant for flight crew operations, then considered to affect the performance of air traffic controllers, and later it was focused on the performance of aircraft maintenance personnel. In the present technology centric air-ground CNS/ATM systems, ATSEP role in the safety chain is crucial to seal all the holes in the last layer of defence. However, human factors of ATSEP are not being addressed or focused on the manner as it is done on the performance of Pilots, AME, ATCOs, MET, ASO and Flight Dispatchers.

The stressful working environment of ATSEP can lead to errors, lapses, latent or error causing conditions that brings the invisible windows of opportunity for unsafe acts, or even fatal accidents. Given the unique nature of the job performance with zero tolerance for error and with the requirements of elevated levels of technical skills, there was a need for defining uniform standards on the roles, responsibilities, deployment, duty pattern, requirement of knowledge, skills, attitude, competency, training, resources, and rewards with regards to ATSEP who are playing vital role in the safety chain.

The International Federation of Air Traffic Safety Electronics Association (IFATSEA) emphasized the importance to study the human factor issues of ATSEP on their working environment, abilities, limitations and on other characteristics for evaluating their job and safety performance at CNS / SG

23 in Bangkok. The meeting considered that establishment of a small working group would be necessary to support such study.

Further, IFATSEA has conducted a global study on human factors of ATSEP to understand the abilities and limitations of Air Traffic Safety Electronics Personal (ATSEP) in their working environment. This global study assessed the present maturity levels of ANSPs in terms of human performance management pertaining to ATSEP. The study found that the human performance management maturity levels of ANSPs w.r.t ATSEP are in the exceedingly initial stages and there are scopes for improvement.



Figure 1: Timeline of ATSEP Human Factors Guidance Material

Based on the study, a report on human factors of ATSEP was presented in CNS SG/24 through web conference, and the meeting has forwarded the draft conclusion for adoption in APANPIRG/31. Consequent upon adoption in APANPIRG/31 and ICAO APAC has issued a state letter for the APAC states for encouraging them to consider the study recommendations for the implementation proactively and come forward to join the small work group for preparation of Regional ATSEP human factors guidance material.

The Ad-hoc work group of experts from Eight (8) member states (China, Hong Kong China, India, Indonesia, Japan, Republic of Korea, Singapore, and Thailand) and IFATSEA was established in April 2021 in response to the Conclusion APANPIRG/31/15-Addressing Human Factor Issues of ATSEP recommended by CNS SG/24 meeting for finding the left-out gaps and for preparing the regional ATSEP human factors guidance material.

Under the leadership of IFATSEA, the Ad-hoc work group has thoroughly discussed the factors that add Stress and Fatigue to ATSEP and deliberated on the effective countermeasures to address those human factors and ANSPs' resilience through countermeasures in the subsequent meetings. Based on this a Stress Factor Mapping Document (SFMD) was prepared.

Furthermore, the Ad-hoc group has deliberated on long term benefits to ANSP and ATSEP community on addressing the human factors, best practices to be adopted by the states to achieve highest level of resilience, and human performance process maturity levels. Deliberations on

priority actions to be taken by ATSEP and ANSP during pandemic like Covid-19 were also carried out. Consequently, the Ad-hoc group has worked on finalizing the structure and drafting of various modules of Regional ATSEP human factors guidance material.

Apart from the periodical meeting held by work group during June 2021 to June 2022, IFATSEA has conducted Global Webinar on Human Performance on 12th November 2021 to deliberate the ATSEP human performance and organizational resilience. IFATSEA has also arranged series of mastermind sessions involving volunteers from the work group on deliberating the issues that affect the human performance and solutions to ensure the highest level of performance.

Consequently, the Ad-hoc workgroup has presented and submitted the draft Regional ATSEP guidance material to the Twenty-Sixth Meeting of the Communications, Navigation and Surveillance Sub-group of APANPIRG CNS SG/26 scheduled during 5th-9th September 2022.

1.3. Concept

1.3.1. Systems Approach

Systems Approach was used to improve the current human resource management process and come up with solutions, which not only address the concerns outlined in this document but also potential future factors of a similar nature.

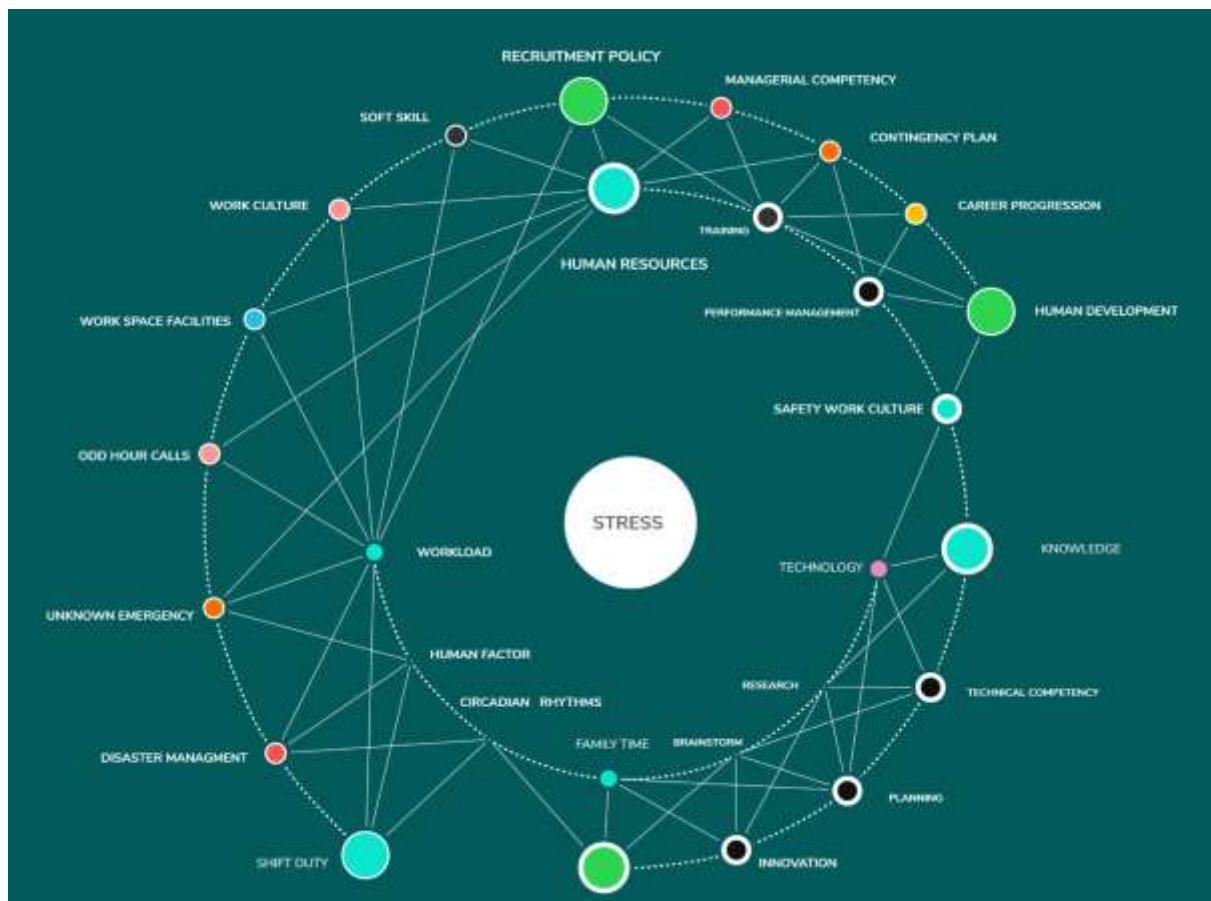


Figure 2: Interlinked Stress Factors and Human Performance

The figure 2 depicts the highly interconnected stress factors that affect job performance and the human performance management process that address these factors. By improving the human performance processes, we can reduce the stress levels of ATSEP, increase their performance and

achieve the safety and service commitment of ANSP even under challenging conditions in other words ANSP reaches elevated levels of resilience.

1.3.2. Mutual benefits for ANSP and ATSEP

The safety and service goals of any ANSP are realized through a key workforce who are strategically related to the mission and vision of the organization. There are several human performance management processes through which required competencies are identified, the right people are resourced, a conducive working environment is provided, people are developed continuously, and their motivation, commitment and engagement are enhanced for high performance.

The safety and service level results of any ANSP are correlated with human performance. If the human performance management procedure is premature or unavailable, they either introduce new stressors or exacerbate current ones. It has an impact on work performance and the favourable factors that produce the desired result in either scenario. So ANSPs cannot achieve the defined safety and service goals.

It is better to evaluate the outcome as well as the process maturity levels and take corrective measures to improve the process and thereby assuring the outcome. When the human performance management processes are at a higher level of maturity, it ensures that desired outcomes and resilience are achieved.

Stress factors can be reduced, and job performance boosted by trying to develop underdeveloped human performance management processes. With the increased job performance, the desired goals are achieved, and new goals can be set and assured.

The mutual benefits to ANSP and ATSEP are examined for each suggested measure. Resilience and financial advantages to ANSP are stated at the conclusion of each measure.

Along with their self-evaluation checklists, ANSP and ATSEP actions to be implemented to attain mutual advantages are listed. Self-evaluation checklists for ANSP are intended to assess both the organisational resilience level and the maturity levels of the human performance process. Based on the idea, self-evaluation checklists are suggested in five chapters for ANSP and ATSEP. The self-evaluation checklists are maintained straightforward to motivate the ANSPs to assess their performance and make improvements.

1.3.3. Pareto rule

The advice material has focused primarily on the countermeasures that are most effective and relevant to the process, which are necessary for any ANSP to increase organizational resilience.

This way by following Pareto rule, 20% of the most influential countermeasures that can address over 80% of the factors that affect the job performance and add stress and fatigue to ATSEP are highlighted as “**Most Influential Countermeasures**” in each chapter. However, the other relevant countermeasures also listed in the end of the chapter.

This guidance material scientifically addresses the challenges for human performance management and aims to provide best practices to be adopted by the states to build resilient ANSPs through ATSEP, those who ensure final defences in the safety chain.

However, the stress factor mapping document (SFMD), entire factors, countermeasures are given in the appendices 1, 2, & 3.

1.3.4. CANSO Standard of Excellence in Human Performance Management

This guidance material has adopted the *CANSO Standard of Excellence in Human Performance Management* model for evaluating the levels of maturities for the self-evaluation of ANSP. The maturity levels are given below for ready reference.

- **Level A – Informal Arrangements** - Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task.
- **Level B – Defined** - Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.
- **Level C – Managed** - Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied.
- **Level D – Assured** - Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.
- **Level E – Optimized** - Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria.

1.3.5. Organizational Resilience

This guidance material has adopted the organizational resilience concepts through human performance for evaluating the levels of resilience for the self-evaluation of ANSP. Brief information on different resilience levels is given below for ready reference.

1.3.5.1. Preventative control: Defensive and Consistent

The characteristic of this level is achieved by means of risk management, physical barriers, redundancy (spare capacity), systems back-ups and standardized procedures, which protect the organization from threats and allow it to ‘**bounce back**’ from disruptions to restore a stable state. i.e., defensive + consistent.

Society expects organizations and critical infrastructures to be safe, secure, and dependable, and that industry, government, regulators, and service-deliverers have appropriate and continually improving capabilities to ensure this.

The goal of regulation is to produce fail-safe system designs. Defences, barriers, safeguards, and back-ups occupy a key position in this approach.

Systems have multiple defensive layers: some are engineered, others rely on people, and yet others depend on procedures and administrative controls.

Organization at it has have the following positive signs:

- Known problems are solved using proven techniques.
- Standard ways to do things are perfected by fine tuning.
- Redundancy through design and diversification has a stabilising effect.
- Disturbances are quickly counteracted by planned responses.

1.3.5.2. Mindful Action: Defensive and Flexible

The characteristic of this level is produced by people, who notice and react to threats and respond effectively to unfamiliar or challenging situations. i.e., Defensive + flexible.

To be resilient is to be prepared for adversity, which requires “improvement in overall capability, i.e., a generalized capacity to investigate, to learn, and to act, without knowing in advance what one will be called to act upon.”

Rather than relying on static controls and reactive responses, Organizational Resilience also requires resources that can be activated, combined, and recombined in new situations, as challenges arise. An important contribution of this stream of work is that people are not regarded purely as sources of error but provide a positive contribution towards resilience.

Thus, the focus of resilience thinking shifted to the need for a culture that facilitates noticing and containing problems. Some organizations, despite operating in complex and dynamic environments and facing many opportunities for failure in their daily operations but almost never experience an operating failure or disruption.

Organization at its best has the following positive signs:

- People are wary about what could go wrong.
- Opportunities and problems are noticed, understood, and addressed quickly.
- People exercise judgement, discretion, and imagination when faced with challenges.
- People are empowered to act when they recognize a problem.

1.3.5.3. Performance Optimization: Progressive and Consistent

The characteristic of this level is formed by continually improving, refining, and extending existing competencies, enhancing ways of working and exploiting current technologies to serve present users and demands i.e., progressive + consistent.

Driven by globalization, the need for downward pressure on costs and the aim of improvements in shareholder value, many organizations have focused on the need to plan, organize for, and realize efficiency gain and increase productivity.

Performance optimization involves learning to do existing things better, delivering goals and meeting the needs of the public, the media, regulators, and the government, who all demand that products and services be delivered that ‘work right this time, next time and every time.’

Typically, optimizing involves process enhancement, including the refinement, extension and exploitation of existing assets and competencies, technologies, and paradigms.

Organization at its best has the following positive signs:

- Performance improvement – ‘do what we do better’
- Known solutions are implemented quickly – even by edict.
- A clear sense of direction, goals, roles, and responsibilities
- A strong individual leader who people can relate to

1.3.5.4. Adaptive Innovation: Progressive and Flexible

The characteristic of this level is created through creating, inventing, and exploring unknown opportunities and new technologies. Organizations can be the disruption in their environment i.e., progressive + flexible.

“It is not the most intellectual of the species that survives; it is not the strongest that survives; but the species that survives is the one that is able to adapt to and to adjust best to the changing environment in which it finds itself.”

In today’s aviation business environment, the rapid production of knowledge and innovation is critical to organizational survival. Innovation involves creative problem-solving, innovation and learning, which have become critical to competitive advantage.

In response to these challenges, organizations can no longer engage in technical change by applying known solutions and current knowledge that can be implemented by experts, they need to engage in adaptive change that “requires going beyond any authoritative expertise to mobilize discovery, shedding certain entrenched ways, tolerating losses and generating the new capacity to thrive anew.” This requires experiments, new discoveries, and invention from numerous places in the organization or community.

Organization at its best has the following positive signs:

- Productive tension disrupts existing patterns and generates a search for new possibilities.
- Creative thinking and problem solving by people drawing on multiple perspectives and taking risks in a safe environment.
- Collective strategic action with rich interactions coalition formation, negotiation, and compromise.
- Systems-wide changes across borders and boundaries; multidimensional and fundamental changes.

1.3.6. Mapping of Resilience Levels and Process Maturity Levels

For an easier comparison evaluation check lists for ANSP.

Table 1: Mapping of Resilience Levels and Process Maturity Levels

Process maturity levels		Resilience levels
Level A & B		Preventative control
Level C		Mindful action
Level D		Performance optimization
Level E		Adaptive innovation

1.3.7. Evaluation method

The guidance material is recommending the corresponding human resource management process improvement and their evaluation than evaluating factor by factor. By improving the process, ANSP will be able to address not only the listed factors but even beyond. At the same time without improvising the process, factors cannot be addressed effectively.

It is recommended to carry the self-evaluation at-least once in a year. When ANSP's self-evaluation is in the level of D or E, then the same may be ascertained with the self-evaluation of ATSEP through a proportionate stratified random sampling. It is recommended to keep the sample size as 10% on each stratum of population and to select different samples each year.

1.4. Safety Roles of ATSEP

The term Air Traffic Safety Electronic Personnel (ATSEP) has been invented to describe those technical specialists working to provide and support the electronics and software, which enable ATS systems to function. ATSEP comprise engineers, technicians, and computer hardware and software specialists who are responsible for the specification, procurement, installation, calibration, maintenance, testing and certification of ground electronic systems used to help control aircraft movements. For that purpose, these people must be trained to have enough background knowledge about air navigation services adding to their own expertise in engineering, technology, hardware/software etc.

ATSEP may perform tasks on a wide variety of CNS/ATM systems and equipment requiring a wide range of competencies and expertise as well as knowledge and skills in electronics, computer sciences and network. In addition, ATSEP activities may be carried out from technician to high-level engineering. [DOC 10057].

The possible scope of ATSEP activities using engineering lifecycle as a basis, include system conception through design, operations and finally decommissioning. In addition to technical activities, others may be added related to management, teaching or assessment, safety management, security management and quality management.

Figure 3 Typical Working Environment of ATSEP

A typical working environment on which ATSEP performs their tasks is depicted in the figure 3. The environment includes people, procedures, and equipment. ICAO SHELL model referred in DOC 9683 is well applicable and addresses the human factor issues of ATSEP.

Active participation and contribution of ATSEP are essential in all the stages of ANS ground facilities, right from the installation to operation. Addressing the human factor issues of ATSEP during these stages are very essential and issues related in the operation environment are incredibly significant, addressing of these issues directly contributes the safety, capacity, and efficiency of ANSP.

ATSEP are expected to perform duties with wide varying environment from high raised tower to cable trenches in the ground, extremely hot open place to temperature-controlled equipment room, remarkably busy cities to very remote places of the state.

The Aviation industry requires 24-hour activities to meet the operational demands. Global growth in the industry will continue to increase these round-the-clock requirements. Air Traffic Service must be available to support 24-hour a day operation to meet these industry demands. Programs for modernizing the air navigation infrastructure in both CNS and ATM are well underway around the globe. The implementation of modern technologies will bring significant benefits to air

navigation service providers and their users. At the same time, a new set of regulations are being established for the implementation and efficient operation of future CNS/ATM systems.

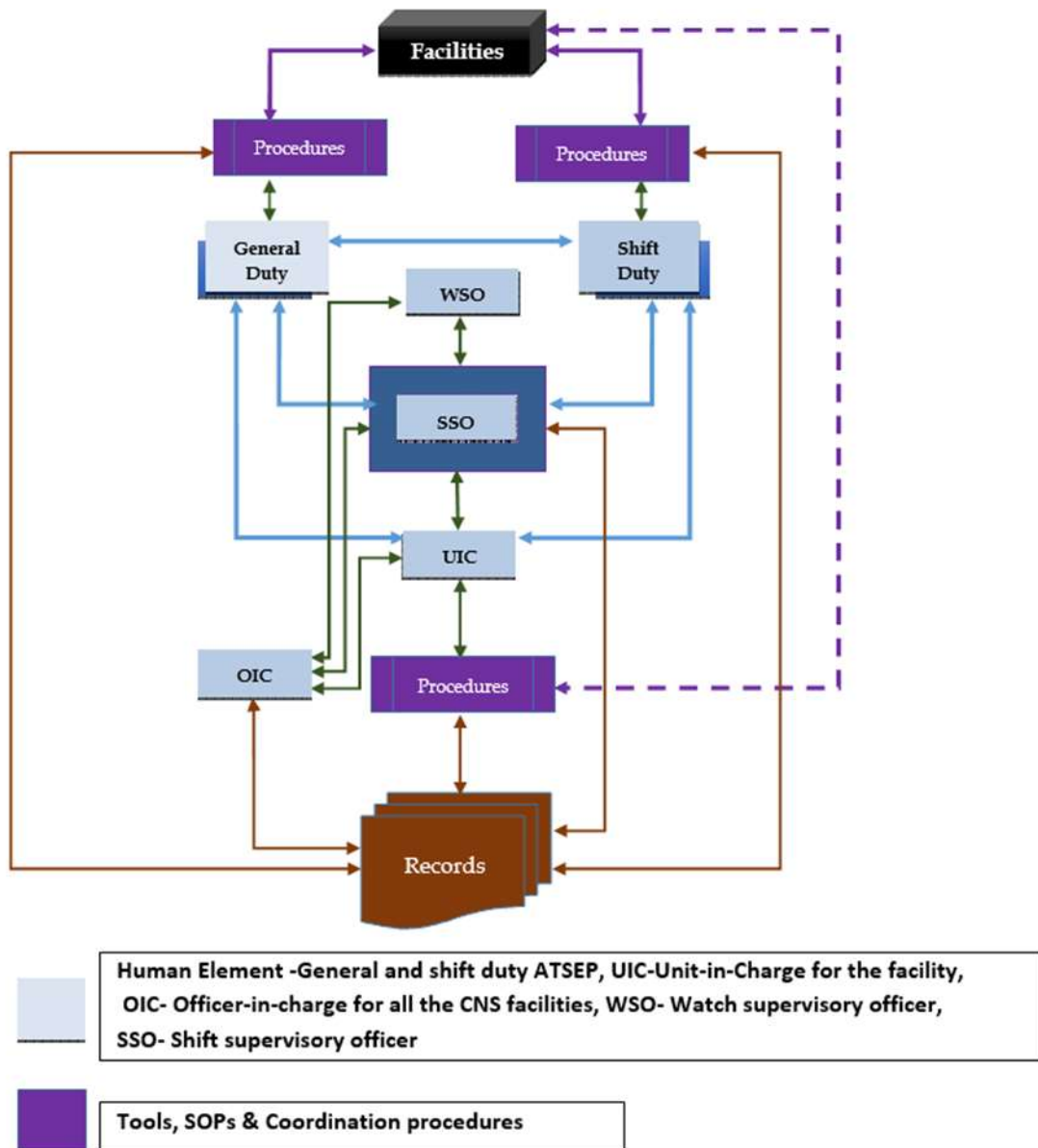


Figure 3: Typical Working Environment of ATSEP

Air Traffic Safety Electronics Personnel (ATSEP) are the authorized personnel who are proven competent to install, operate, maintain, release, and return into operations CNS/ATM equipment. It needs to ensure they have qualified and competent ATSEP to install maintain and operate, at optimum performance and resilience, these globally interconnected and complex CNS/ATM systems.

ATSEP are responsible for the provision of required communication, navigation, and surveillance performance, which are critical enablers to ensure Performance-Based Navigation (PBN) in any given airspace as stipulated by ICAO. High availability, accuracy, continuity, and resilience of these services are especially crucial factors in the aviation business. Unreliable CNS services lead to delays and increased pilot and controller workload.

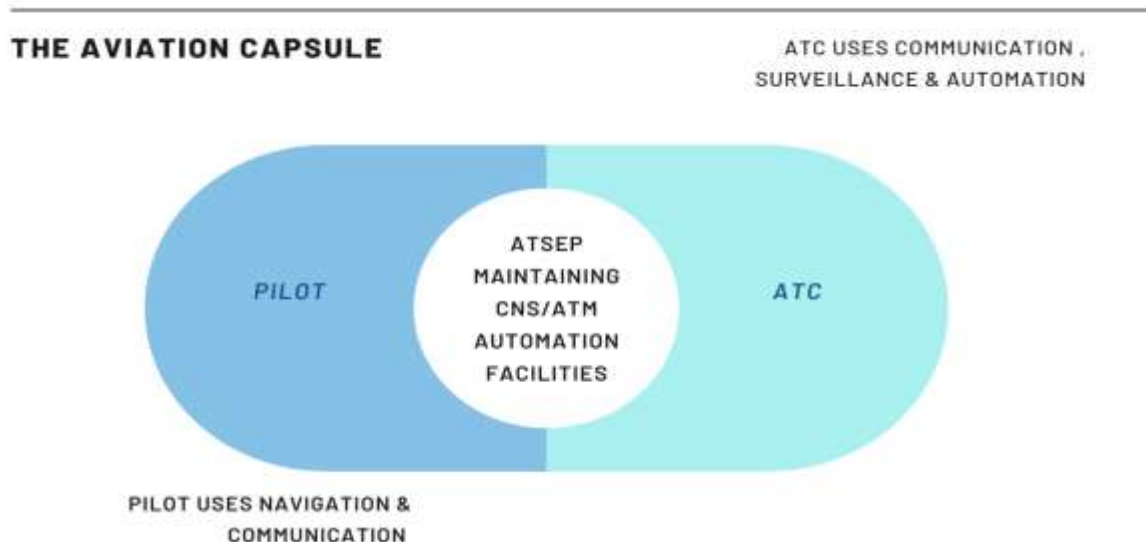


Figure 4: Aviation Capsule

Thus, the availability and continuity of ATM/CNS services impacts efficiency and increases user costs. Similarly, an ATM system failure can have major consequences. Traffic patterns of an entire flight information region can be affected with significant impact on flight schedules, increased fuel burn, and a more complex air traffic control environment.

Civil aviation is based on a worldwide interoperable system involving air and ground infrastructure, procedures, and regulations to ensure safe, efficient, and effective operations. These interconnected systems pose cybersecurity challenges in ATM. ATSEP are in the forefront of addressing cybersecurity issues as soon as they appear in these interconnected systems.

ATSEP are responsible for ensuring the integrity and availability of the information used by both pilots and ATCO. Services performed by ATSEP have been proven throughout the years as critical to ensuring safety and efficiency in the civil aviation.

ATSEP must ensure the resilience of the entire system in a standardized manner. New cybersecurity challenges in CNS/ATM (e.g., Remote Towers) ATSEP are in the forefront of addressing cybersecurity issues and threats equally in the networked ATM systems, at remote CNS facilities or for the 'signal in space.' These professionals need to be trusted, competent and responsible. Identifying a technical failure from a cybersecurity breach is a significant responsibility for ATSEP.

The ATM system is evolving towards a globally integrated and collaborative system. Air traffic safety electronics personnel (ATSEP) involved in the installation, operation and maintenance of the CNS/ATM system must have a shared understanding of what is expected of them in terms of performance wherever they may work to support a globally interoperable system and to achieve optimum capacity within acceptable safety limits. This shared understanding becomes critical when considering the increasing traffic and the growing complexity and interconnectedness of the systems involved.

1.4.1. Activities.

1.4.1.1. Operational activities.

Supervision, monitoring, control, and reporting in real time of technical services, supported by electronic systems and/or equipment for CNS/ATM.

1.4.1.2. Maintenance activities.

Preventive maintenance, corrective maintenance and/or modification and updates of supporting electronic systems and/or equipment for CNS/ATM.

1.4.1.3. Installation activities.

Project management, specification, conception, validation, integration, test and acceptance, safety assessment, calibration, certification, optimization, and upgrade of supporting electronic systems and/or equipment for CNS/ATM, engineering activities.

1.4.2. Unique characteristics of ATSEP working environment.

Operational environments, such as the flight deck or the ATC room, pilot or the controller will see the effects of the error before the aircraft completes its flight. It does not always apply to aircraft maintenance error. In contrast to the "real-time" nature of error in ATC and the flight deck, aircraft maintenance errors are often not identified at the time the error is made.

Whereas in case of ATSEP working environment, the error caused during the operation of the system will be known immediately to ATC as well as to ATSEP as they always work in the live system. At the same time any error caused during the installation, testing and commissioning stages will not be known immediately when the error is made.

ATSEP are expected to attend the degraded system live and always under pressure to make the system available in fullest capabilities. Unless otherwise there is a total breakdown, ATSEP carry their preventive and corrective maintenance works when the systems are working either in full capable mode or in degraded mode of operation. This makes their working environment unique among the safety chain stakeholders.

1.5. Outcomes and Endorsements

The International Federation of Air Traffic Safety Electronics Associations (IFATSEA) emphasized the importance to study the human factor issues of ATSEP on their working environment, abilities, limitations and on other characteristics for evaluating their job and safety performance at CNS / SG 23 in Bangkok. The meeting considered that establishment of a small working group would be necessary to support such study.

Based on the study, a report on human factors of ATSEP was presented in CNS SG/24 through web conference, and the meeting has forwarded the draft conclusion for adoption in APANPIRG/31. Consequent upon adoption in APANPIRG/31 and ICAO APAC has issued a state letter for the APAC states for encouraging them to consider the study recommendations for the implementation proactively and come forward to join the small work group for preparation of Regional ATSEP human factors guidance material.

The Ad-hoc work group of experts from Eight (8) member states (China, Hong Kong China, India, Indonesia, Japan, Republic of Korea, Singapore, and Thailand) and IFATSEA was established in April 2021 in response to the Conclusion APANPIRG/31/15-Addressing Human Factor Issues of ATSEP recommended by CNS SG/24 meeting for finding the left-out gaps and for preparing the regional ATSEP human factors guidance material.

1.6. Arrangements of this document

The regional ATSEP human factors guidance material has the following parts.

- (1) Introduction,
- (2) Reference Documents,
- (3) People Resourcing,
- (4) Job, Role and Skills Analysis and Competency Modelling,
- (5) Knowledge Management, Talent Management, Learning and Development,
- (6) Induction Of New Systems and Maintenance Philosophy,
- (7) Work Environment, Well-Being, Performance, And Reward,
- (8) Motivation, Commitment, And Engagement,
- (9) Behavioural And Role Specific Competencies,
- (10) Safety Culture Promotion.

In addition to the above the guidance material has the following appendices

(1) Stress factor mapping (2) Stress factors, (3) Countermeasures, (4) ATSEP duty time limitation, (5) Measures during Pandemic, (6) Progressive Training, (7) Stress management, (8) Safety culture and (9) Consolidated Checklist Evaluation.

Appendix (1) Stress factor mapping document to be printed on A3 size if hard copy is preferred.

1.7. Document History and Management

This document was introduced in the CNS SG/26 meeting (5th September 2022 to 9th September 2022) for review and adoption.

1.8. Copies

Paper copies of this document are not distributed. Controlled and endorsed copies can be found at the following website: <http://www.icao.int/APAC/Pages/edocs.aspx> and may be freely downloaded from the website, or by emailing APANPIRG through the ICAO Asia and Pacific Regional Office who will send a copy by return email.

1.9. Changes to this document

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (see Section 1.11 below) should be completed and submitted to the ICAO Asia and Pacific Regional Office. The Regional Office will collate RFCs for consideration.

When an amendment has been adopted by the meeting of the CNS SG, then a latest version of the regional ATSEP human factors guidance material will be prepared, with the changes marked by an “|” in the margin, and an endnote indicating the relevant RFC, so a reader can see the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted, e.g.:

Final approval for publication of an amendment to this will be the responsibility of APANPIRG.

1.10. Editing Conventions

(Intentionally blank).

1.11. ATSEP Human Factors Guidance Material - Request for Change Form.

Please use this form when requesting a change to any part of this **ATSEP human factors guidance material**. This form may be photocopied as required, emailed, faxed, or e-mailed to ICAO Asia and Pacific Regional Office +66 (2) 537-8199 or APAC@icao.int.

Table 2: ATSEP Human Factors Guidance Material - RFC Form

1. SUBJECT:			
2. REASON FOR CHANGE:			
3. DESCRIPTION OF PROPOSAL: [expand / attach additional pages if necessary]			
4. REFERENCE(S):			
5. PERSON INITIATING:			DATE:
ORGANIZATION:			
TEL/FAX/E-MAIL:			
6. CONSULTATION RESPONSE DUE BY DATE:			
	Organization	Name	Agree/Disagree
7. ACTION REQUIRED :			
8. DAPs IGD EDITOR			DATE REC'D :
9. FEEDBACK PASSED			DATE :

1.12. Amendment Record.

Amendment Number	Date	Amended by	Comments
0.1			

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2. REFERENCE DOCUMENTS

Table 3: Reference Documents

Id	Name of the document	Edition	Date	Origin	Domain
1	Human Factors Training Manual Doc no.: 9683 - AN/950	1 st Edition	1998	ICAO	
2	DOC 10057 Manual on Air Traffic Safety Electronics Personnel Competency-based Training and Assessment	Second Edition	2020	ICAO	
3	Doc 9868 - PROCEDURES FOR AIR NAVIGATION SERVICES – Training.	Third Edition	2020	ICAO	www.icao.int
4	Annex 19 – Safety management	Second Edition	2016	ICAO	
5	Doc 9859 - Safety Management Manual	Fourth Edition	2018	ICAO	
6	CANSO Standard of Excellence in Human Performance Management	-	2019	CANSO	
7	ATM Safety Framework Maturity Survey – Methodology for ANSPs	1 st Edition	2009	Eurocontrol	
8	DAS/HUM, Fatigue and Sleep Management Personal strategies for decreasing the effects of fatigue in Air Traffic Control	-	15 Jan 2018	Eurocontrol	
9	APX. R - Factors adding stress and fatigue to ATSEP of WP 25 of CNS SG/24		04-12-2020	IFATSEA	www.icao.int
10	Concise study report of Human Factor Study of ATSEP		31-03-2021	IFATSEA	www.ifatsea.org
11	The circadian rhythm in balance				www.parans.com
12	Manipulating the sleep-wake cycle and circadian rhythms to improve clinical management of major depression			BMC Medicine	www.biomedcentral.com

Id	Name of the document	Edition	Date	Origin	Domain
13	Organizational Resilience: A summary of Academic evidence, Business insights and new thinking by BSI and Cranfield	1 st Edition	2017	School of Management BSI and Cranfield University	
14	Just Culture Manual for ATCO, ANSE & ATSEP - Marc Baumgartner and Reto Schorer	1 st Edition	2017	SwissATCA	
15	Benchmarking Best Practices in Maintenance, Reliability and Asset Management - Terry Wireman	Third Edition	2015	Industrial Press, Inc.	
16	Essential Guide to Knowledge Management - Shawn Marshall	First Edition	2017	Library Press	
17	Stress at Work - Management and Prevention - Jeremy Stranks	1 st Edition	2005	Elsevier Butterworth-Heinemann	
18	Managing stress – Principles and Strategies for health and well-being – Brian Luke Seaward	Ninth Edition	2018	Jones & Bartlett Learning	
19	Human Resource Management - ROBERT L. MATHIS and JOHN H. JACKSON	13th Edition	2010	Cengage Learning.	
20	Fundamentals of Human Resource Management - DAVID A. DeCENZO, STEPHEN P. ROBBINS, SUSAN L. VERHULST	11 th Edition	2013	John Wiley & Sons, Inc.	
21	Armstrong's Handbook of Human Resource Management Practice - MICHAEL ARMSTRONG and STEPHEN TAYLOR	13th Edition	2014	Koganpage	
22	People Resourcing and talent planning - STEPHEN PILBEAM and MARJORIE CORBRIDGE	Fourth Edition	2010	Pearson Education Limited	



CHAPTER 3 PEOPLE RESOURCING

This chapter discusses the importance of people resourcing in strategic human resource management for organizations, specifically in the context of Air Navigation Service Providers (ANSP) and Air Traffic Safety Electronics Personnel (ATSEP).

THE OBJECTIVE

The benefits of effective people resourcing for ANSPs and ATSEPs include optimal human resource requirements, competitive advantage, reduced tension and exhaustion, and positive psychological contracts.

The actions taken by ANSPs and ATSEPs to achieve strategic people resourcing include workforce planning, recruitment and selection, and talent management.

The most influential countermeasures for people resourcing include regular optimization of human resources and assessing optimal manpower requirements.

“It is people that control aircraft, it is people that maintain equipment and it is people that create safety.”

- Human Performance Management - CANSO.

3. PEOPLE RESOURCING

3.1. Introduction

Through people resourcing, human resource management (HRM) objectives are strategically incorporated with organisational performance. Through effective people resourcing, an organisation may attract and retain the right number of individuals who are qualified, motivated, and engaged in adding value to the organisation and its stakeholders.

3.2. Benefits to ANSP

Optimum human resource requirements are worked out through workforce planning based on the projected changes in the types of activities carried out by the ANSP and the scale of those activities. Examples – New CNS/ATM projects, new airports, new runway, increased operational hours and additional facilities in the existing airport.

Ensures that ANSP achieves competitive advantage by recruiting, retaining, and developing more capable people and retains the talent by providing better opportunities, rewards, and conditions of employment. Even though all the systems are made human centric, the rapid growth and usage of technology impacts the air traffic to greater extent, leads to considerable monetary loss, damage to the reputations of ANSP and safety issues during technical snags. Examples – FIR / ACC closures, diversions, delays, and cancellations.

Matching human resources to the ANSP's culture, strategic goals, and operational needs ensures optimal use of those resources. When the recruiting and retention of talent are ensured throughout time, ANSP develops a brand value and draws talent from the market using the retained talents.

3.3. Benefits to ATSEP

Strategic people resourcing results in reduced tension and exhaustion owing to a sustainable workload and adequate breaks. ATSEP can share responsibilities more effectively with teammates who are equally competitive and efficient. Positive psychological contract results in greater commitment, trust, and engagement between parties. A healthier workplace environment also results in longer, more enjoyable family time.

3.4. Actions by ANSP

Strategic resourcing: It is concerned not only with obtaining and keeping the number and quality of staff required but also with selecting and promoting people who 'fit' the culture and the strategic requirements of the organization. It also deals with ensuring full utilization of those resources.

Workforce planning: This process identifies anticipated changes to the scope and nature of the organization's activities. It defines the essential skills and behaviours that the company needs to accomplish its objectives.

Recruitment and selection - it deals with finding and engaging the right people for the organization needs.

Talent Management - The process of ensuring that an organization has the talented people it requires to achieve its safety goals is known as talent management. It entails creating and maintaining a talent pipeline to strategically manage the flow of talent through an organization.

3.5. Actions by ATSEP

Understanding the culture and strategic requirements of the organisation aids ATSEP in increasing engagement and commitment to create mutual trust and the psychological contract. They add unique value to the organisation through their talent and skills.

3.6. Most Influential Countermeasures

The stress and fatigue levels of ATSEP can be reduced and safety goals can be met with regular optimum augmentation of human resources based on existing tasks, expected retirements, and expected additional facilities.

Assessing optimal manpower requirements, recruiting competent people, training, deploying, and promoting accordingly.

3.7. Human Factors Issues Addressed

3.7.1. Directly Addressed Factors

The following factors are addressed directly by the process of people resourcing i.e., by provisioning the optimum human resources all the time.

1	Approval of projects without looking into the resource's requirements like human, vehicles, and other support. Workload increases on coordinating for essential supporting resources and prevents the concentration on core project activities as well as to skip the maintenance activities of ongoing operational facilities.
2	Combined project and operational tasks.
3	Continuous works including weekends during the demanding situations for meeting the special maintenance and project works along with routine operational works.
4	Extra shift duties are forced due to shortage of manpower
5	Forced to carryout major maintenance works only during late night and need to return to duty next day by 0930AM.
6	Frequent changes in the team members or team lead prevents better teamwork and communications.
7	Improper and unbalanced work distribution with undue over burden and undue over leniency.
8	Inhibition of valuable suggestions and ideas due to the overload of works.
9	Innumerable, unspecified, and unpredicted works assigned to selected ATSEP preventing their attention from core maintenance tasks.
10	Irregular duty calls without any pattern due to shortage of manpower
11	Lack of competitive colleagues. People with substandard knowledge and skills are getting selected.
12	Lack of fresh recruitments, but more retirements and induction of new equipment.
13	Lack of job rotation and equal opportunities.
14	Lack of pride as not recognized as expert in particular field and transferred anywhere without considering the competencies acquired.
15	Lack of project management skills and competencies at the same time, simultaneous operation and projects tasks given with unrealistic timelines.
16	Lack of support on career development and career plan.
17	Lack of time to family

18	Leave requests not approved
19	Must report again by 0930AM even after late night breakdown calls and late-night project works.
20	No alternate/standby operational team to share the workload even at emergency.
21	No clear OFFs before shift pattern changes
22	No standardized duty pattern, duration, breaks and rest periods
23	Non deployment of competent persons in right place after equipment training.
24	Permanent combined duties due to shortage of manpower increases workload and reduces the attention in all the combined units.
25	Selection criteria for inducting various levels of ATSEP for ensuring more competent people recruited in the higher levels.
26	Simultaneous project supervision and maintenance activities without additional manpower.
27	Single man shift.
28	Too many additional facilities added into ANSP like RADARS, CNS/ATM automation facilities, Nav-Aids at new airports and new RWYs in the last decade, without augmenting the human and other resources.

3.7.2. Indirectly Addressed Factors

The following factors are addressed indirectly by the process of people resourcing i.e., by provisioning the optimum human resources all the time.

1	Acceptance of inefficient manpower by management without any mitigation.
2	Additional tasks assigned by regional and or corporate head quarter in addition to local airport works. (QR preparation, tender evaluation, course development, etc.,)
3	Annual plan for ATSEP training and development in line with the operational and competency requirements.
4	Expected competencies in all domains of CNS/ATM systems.
5	Difference in stated corporate Mission/Vision and the ground reality.
6	Lack of equipment training even after years of deployment in the unit.
7	Lack of KS and Competency to manage complex modern equipment.
8	Lack of opportunity for developing and or retaining core competencies due to deployment in non-core areas for a prolonged period before and after equipment training.
9	Lack of opportunity to develop expertise on networking, operating systems, cyber security, project management etc. due to lack of in-house expertise instructors and training infrastructure.
10	No clear demarcation of competencies so spending more time on KSC update on all areas without even having the access to the equipment and facilities. (Too many make and models)
11	No clear demarcation of technical and managerial responsibilities among the junior ATSEP and senior ATSEP.
12	Sleep loss due to irregular shift pattern or fast rotating shift pattern
13	Too many unclassified additional works in smaller airports. Essential maintenance tasks skipped.
14	Uncertainty on future roles and responsibilities.

3.7.3. Additional Factors Addressed

The following additional factors that are addressed, which are aggravating stress and fatigue when the workload is more, and the human resources are less.

1	Different make and model for each facility / system.
2	Deployment in non-core activities for longer duration.
3	Compulsory movements within the nation during service life
4	Less human resources for core jobs but deployment in non-core areas like terminal management, security systems, airport systems, administration works, commercial, and general stores.
5	Manhours spent in Cargo, Customs clearance, without proper expertise or supporting staff instead of spending time on critical maintenance works and project works.
6	Multiple jobs of diversified nature in quick successions without notice or planning.
7	Often project deadlines are set without freezing the scopes and augmenting with necessary resources.
8	Where there is electronics, there shall be an ATSEP – Belief of airport in-charges.

3.8. Self-Evaluation Checklist

3.8.1. Self-Evaluation Checklist for ANSP

Human performance management processes maturity level Self-Evaluation Check list for ANSP – PEOPLE RESOURCING				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Strategic people resourcing for directly addressing the factors that are adding stress and fatigue to ATSEP due to over workload and due to lack of human resources	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria	
2)	Strategic people resourcing for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to over workload and due to lack of human resources		Level A	
			Level B	
			Level C	
			Level D	
			Level E	

3)	Strategic people resourcing for addressing the factors that are aggravating stress and fatigue when the workload is more, and human resources are less	Level A	
		Level B	
		Level C	
		Level D	
		Level E	
4)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation	
5)	If maturity level is D w.r.t score of (1)		
	Do you have workforce planning based on projected changes?		Y/N
	Did you recruit people as per the workforce planning?		Y/N
	Did you provide better opportunities and better working conditions to your people?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>		
6)	If maturity level is E w.r.t score of (1)		
	Did you revise the workforce planning in the last two years?		Y/N
	Did you revise the recruitment process to suit the safety and service strategy?		Y/N
	Are you able to get more competitive people successively from the market?		Y/N
	Have you set the key performing indicators for measuring the above?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>		
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>			

3.8.2. Self-Evaluation Checklist for ATSEP

Human performance management processes maturity level Self-Evaluation Check list for ATSEP – PEOPLE RESOURCING					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood the strategic requirements of my ANSP?			Y/N
	B	I have psychological contract with ANSP, that has built the mutual trust, increased commitment, and engagement.			Y/N
	C	I have improvised my unique talent and skills and adding values to my ANSP			Y/N
2)	If your choice for one or more questions is “N,” please state the specific reasons				
	A				
	B				
	C				

3.9. Resilience and Cost Benefits

These actions incur negligible additional costs because only process improvement is required in the already established human resource management system.

In contrast, the organisation will save money overall for the following reasons: (1) optimum human resources are made available only in accordance with their safety and service strategy, and they are fully utilised on the core areas. (2) Ensures competitive advantage by developing and retaining safety-critical talent. (3) With increased employee commitment, the organisation transforms into a high-performing one.

In terms of organizational resilience, ANSP can reach the level of adaptive innovation.



CHAPTER 4

JOB,ROLE,SKILLS ANALYSIS & COMPETENCY MODELLING

This chapter discusses the importance of job, role, skill, and competency modelling in organizational and job design, recruitment and selection, performance management, learning and development, management development, career management, job evaluation, and the design of grade and pay structures. It also outlines the benefits of implementing a performance management system that includes clearly defined key result areas, accountability, and expected outcomes.

THE OBJECTIVE

The actions that ANSP and ATSEP can take to improve job performance and safety are discussed, including defining roles and responsibilities, understanding key result areas, and competency requirements, and developing the necessary knowledge and skills. The most influential countermeasures are identified as defining roles and responsibilities, limiting the stream of competency among CNS/ATM facilities, and restricting the deployment of ATSEP within the scope defined in DOC 10057.

“The ATM system is evolving towards a globally integrated and collaborative system. Air traffic safety electronics personnel (ATSEP) involved in the installation, operation and maintenance of the communication, navigation, surveillance/air traffic management (CNS/ATM) system must have a shared understanding of what is expected of them in terms of performance wherever they may work to support a globally interoperable system and to achieve optimum capacity within acceptable safety limits.”

**DOC 10057 -MANUAL ON ATSEP COMPETENCY BASED
TRAINING**

4. JOB, ROLE AND SKILLS ANALYSIS AND COMPETENCY MODELLING

4.1. Introduction

The analysis of job, role, skill, and competency modelling provides the information needed to create job descriptions, roles and learning requirements. They are critical in organisational and job design, recruitment and selection, performance management, learning and development, management development, career management, job evaluation, and the design of grade and pay structures.

4.2. Benefits to ANSP

A robust performance management system with clearly defined key result areas, accountability, and expected outcomes help in effectively grooming the key workforce with clearly defined learning specifications and personal specifications, which in turn results in lower costs as only necessary training investments are made.

Individuals and teams perform better because both behavioural and functional competencies are well defined. Job design, recruitment and selection, performance management, learning and development, management development, career management, job evaluation, and grade and pay structure design are all done in accordance with the organization's safety and service strategy.

4.3. Benefits to ATSEP

Reduced stress due to unambiguous job profile, clear communication on accountabilities and expected outcome.

Defined key result areas facilitate the motivation towards knowledge and skills update to achieve an acceptable level of performance. Defined behavioural competencies expectations facilitate the motivation in improving the behavioural competencies.

4.4. Actions by ANSP

Job descriptions based on job analysis - Job analysis gives the information on what the job holder is expected to contribute, to whom the job holder reports and who reports to the job holder, the nature and scope of the job in terms of the tasks and operations to be performed and the duties to be carried out. The job description includes the job title, the function in which the job is performed, and the job level within that function. Based on the job analysis, the job description also includes the main activities, tasks, or duties. Job descriptions are extremely specific, giving a clear indication of what must be done, what is done, and the purpose of the activity in terms of outcomes, outputs, or standards to be met.

Role analysis and role profile - identifying inputs – KSAs (knowledge, skill, and attitude), competency requirements (behavioural and functional) and required outcomes (key result areas or accountabilities). A role profile is initially set out under the same headings as a job description, i.e., role title, responsible to, responsible to role holder, and the purpose of the role, but it then focuses on the following aspects of the role: key result areas; knowledge, skills and abilities required; behavioural competencies.

Competency modelling based on skill analysis and job analysis - Skills analysis determines the skills required to achieve an acceptable standard of performance. It is primarily used for technical, craft, manual, and office jobs as the foundation for developing learning and training programmes. Skills analysis begins with a broad job analysis and then delves into the specifics of not only what job holders must do, but also the abilities and skills required to do so. Individual-level competencies that are core or common for an occupational group, entire level of jobs (e.g., executive, management, supervisory, hourly), or the organisation are typically described by competency modelling approaches. Competency modelling is the basis for defining behavioural and technical competencies. Behavioural competencies are the behaviours that organisations expect their employees to exhibit in the course of their work.

4.5. Actions by ATSEP

Understanding the key result areas, and accountabilities for their roles. Understanding the knowledge, skill, and competency requirements for their roles. Developing the knowledge and skills needed to achieve an acceptable level of performance.

4.6. Most Influential Countermeasures

By defining the roles and responsibilities clearly along with accountabilities, individual job performance of ATSEP will increase and in-turn over all safety performance of ANSP will also increase.

Improving the safety job performance of ATSEP by restricting their deployment within the scope defined in DOC 10057.

By limiting their stream of competency among CNS/ATM facilities, higher levels of expertise and competencies can be developed and retained.

4.7. Human Factors Issues Addressed

4.7.1. Directly Addressed Factors

1	Acceptance of inefficient manpower by management without any mitigation.
2	Annual plan for ATSEP training and development in line with the operational and competency requirements.
3	ATSEP desire for recognition on all the facilities (CNS/ATM Automation) and on different makes and models.
4	Combined project and operational tasks.
5	Deployment in non-core activities for longer duration.
6	Diversified tasks during duty.
7	Expected competencies in all domains of CNS/ATM systems.
8	Forced to do tasks even without qualification (attending power lines of UPS and working at heights etc..)
9	Gender bias and equal field works not assigned to women ATSEP.
10	Improper and unbalanced work distribution with undue over burden and undue over leniency.
11	Innumerable, unspecified, and unpredicted works assigned to selected ATSEP preventing their attention from core maintenance tasks.
12	Lack of delegation or poor overlapping delegation and preferences towards frontline tasks not on managerial or leadership tasks.

13	Lack of leadership in communicating the priorities to sub-ordinates.
14	Lack of mutual performance assessment as per the roles and responsibilities assigned.
15	Lack of opportunity for developing and or retaining core competencies due to deployment in non-core areas for a prolonged period before and after equipment training.
16	Lack of opportunity to develop expertise on networking, operating systems, cyber security, project management etc. due to lack of in-house expertise instructors and training infrastructure.
17	Lack of pride as not recognized as expert in particular field and transferred anywhere without considering the competencies acquired.
18	Lack of regulatory requirements for complying standardized trainings and licencing to ATSEP
19	Lack of scientific annual performance assessment and rewarding scheme considering the unique working environment and expected level of performance of ATSEP.
20	Lack of teamwork, more dependency on individuals and collective inputs not taken by team lead for decision.
21	Less human resources for core jobs but deployment in non-core areas like terminal management, security systems, airport systems, administration works, commercial, and general stores.
22	Manhours spent in Cargo, Customs clearance, without proper expertise or supporting staff instead of spending time on critical maintenance works and project works.
23	Multiple jobs of diversified nature in quick successions without notice or planning.
24	No clear demarcation of competencies so spending more time on KSC update on all areas without even having the access to the equipment and facilities. (Too many make and models)
25	No clear demarcation of technical and managerial responsibilities among the junior ATSEP and senior ATSEP.
26	No clear job description, roles and responsibilities are varying after each movement, deployed at non-core areas.
27	Non deployment of competent persons in right place after equipment training.
28	Poor workload distribution makes few carries stress, pressure, fatigue, and timeline pressure throughout without any relief.
29	Uncertainty on future roles and responsibilities.
30	Where there is electronics, there shall be an ATSEP – Belief of airport in-charges.

4.7.2. Indirectly Addressed Factors

1	Always under pressure to give back the facilities within the EST of NOTAM
2	Compromising qualities, essential OEM documentations, training and after acquisition supports on new systems against the cost (L1).
3	Compulsory movements within the nation during service life
4	Constant mind switchover between old and modern technologies, procedures, tools etc., within the same service facilities. Different aged, make and model of equipment within a single service facility like VHF, Nav-Aids, and surveillance.
5	Delayed annual and other planned preventive and corrective maintenance due to non-availability of time for maintenance actions.
6	Delayed flight calibration due to poor preparation and planning.
7	Difference in stated corporate Mission/Vision and the ground reality.
8	Different make and model for each facility / system.

9	Expectations on making quick decision, in less reactive time with zero error tolerance and on fixing the system immediately.
10	Extraordinary file work delays in getting approvals for proceeding to next stages.
11	Lack of equipment training even after years of deployment in the unit.
12	Lack of fresh recruitments, but more retirements and induction of new equipment.
13	Lack of job rotation.
14	Lack of knowledge and expert support while trying to fix an unfamiliar technical glitch.
15	Lack of knowledge in handling emergencies and disastrous situations.
16	Lack of KS and Competency to manage complex modern equipment.
17	Lack of support on career development and career plan.
18	Little or no-hands on training
19	Managing the procurement tasks and maintenance tasks of multiple airports in addition to the local.
20	Single man shift.

4.8. Self-Evaluation Checklist

4.8.1. Self-Evaluation Checklist for ANSP

Human performance management processes maturity level Self-Evaluation Check list for ANSP – JOB, ROLE AND SKILLS ANALYSIS AND COMPETENCY MODELLING				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Job, role and skills analysis and competency modelling for directly addressing the factors that are adding stress and fatigue to ATSEP due to ambiguities on accountabilities and responsibilities.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria.	

2)	Job, role and skills analysis and competency modelling for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to ambiguities on accountabilities and responsibilities.	Level A	
		Level B	
		Level C	
		Level D	
		Level E	
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation	
4)	If maturity level is D w.r.t score of (1)		
	Do you have clear job description?		Y/N
	Did you have clear role profile?		Y/N
	Do you have competency modelling of both behavioural and functional competencies?		Y/N
	Do you have annual training plan prepared based on the role profiles of ATSEP?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>		
5)	If maturity level is E w.r.t score of (1)		
	Have you done the job evaluation of your ATSEP job role profiles in the last two years?		Y/N
	Have you recruited new ATSEP based on the outcome of this process?		Y/N
	Is ATSEP performance management system designed as per the outcome of this process?		Y/N
	Have you set the key performing indicators for measuring the above?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>		
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>			

4.8.2. Self-Evaluation Checklist for ATSEP

Human performance management processes maturity level					
Self-Evaluation Check list for ATSEP – JOB, ROLE AND SKILLS ANALYSIS AND COMPETENCY MODELLING					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood the key result areas and accountabilities of my role			Y/N
	B	I have understood the knowledge, skill, and competency requirements for my role			Y/N
	C	I have developed the knowledge and skills needed to achieve an acceptable level of performance			Y/N
2)	If your choice for one or more questions is “N,” please state the specific reasons				
	A				
	B				
	C				

4.9. Resilience and Cost Benefits

These actions incur negligible additional costs because only process improvement is required in the already established human resource management system.

However, the organisation will save money on training investments and developing key personnel in accordance with learning specifications and personal specifications. Evaluations of the outcome in key areas for which recruitment was done are made using efficient performance management systems. Organizations transform into high-performing organisations by developing the key workforce's behavioural and functional competencies.



CHAPTER 5

KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT

This chapter discusses the benefits of knowledge management, talent management, and learning and development for an organization, particularly an Air Navigation Service Provider (ANSP), as well as the actions that ANSP and Air Traffic Safety Electronics Personnel (ATSEP) can take to improve their knowledge and skills.

THE OBJECTIVE

ANSP can establish a knowledge management system, create talent planning and resourcing plans, integrate learning and development programs with safety and service strategy, and design performance-related learning programs.

Meanwhile, ATSEP can invest time in knowledge update, organize and share unique knowledge, engage in self-directed learning, develop leadership and management skills, and prepare to assume higher responsibilities.

The most effective countermeasures for ATSEP are thought to be the provision of only verified and validated SOPs as well as ANSP level scientific knowledge management on operations, maintenance, projects, and emergencies.

“Human factors (HF) encompass knowledge from a range of scientific disciplines that support human performance (HP) through the design and evaluation of equipment, environments and work, in order to improve system performance.”

DOC 10151 -MANUAL ON HUMAN PERFORMANCE

5. KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT

5.1. Introduction

Knowledge management - Knowledge management is concerned with storing and sharing the wisdom, understanding and expertise accumulated in an enterprise about its processes, techniques, and operations. It treats knowledge as a key resource. Knowledge management is about getting knowledge from those who have it to those who need it to improve organizational effectiveness. Knowledge management identifies relevant information and then disseminates it so that learning can take place. It promotes the sharing of knowledge by linking people with people and by linking them to information so that they learn from recorded experiences.

Talent management - Talent management contains strategies and protocols for the systematic attraction, identification, development, retention, and deployment of individuals with high potential who are of value to an organization. Talent management is the process of ensuring that an organization has the talented people it requires to achieve its safety and service objectives.

Learning and Development - Learning and development strategies and practices, aim to ensure that people in the organization acquire and develop the knowledge, skills, and competencies they need to carry out their work effectively and advance their careers to their own benefit and that of the organization. Individuals are given the opportunity to learn, frequently on their own, with guidance and support.

5.2. Benefits to ANSP

Cost benefits due to early completion of the task, even problematic tasks are solved early. Efficient utilization of man-hours and environment for innovation and organizational learning. Managed intellectual capitals in the organization. Increased organization performance due to established shared understanding.

Cost benefits on hiring and developing. Provides means for developing the organization from within by using job experience, coaching, and mentoring to cultivate the potential in managers. Ensures the availability of talents it needs to attain its safety and service goals. Provides the organization a long-term recruiting strategy and valuable human capital. Strategically implemented talent management ensures systematic attraction of talent, identification, development, retention, and deployment of individuals with high potential who are of value to an organization.

Organization can deliver the safety and service objective cost effectively due to the availability of human resource having the required competencies. Overall improved performance due to the mechanism that ensures the improvement of individuals as well as teams. Effective utilization of resources in learning and development through self-managed learnings.

5.3. Benefits to ATSEP

Reduced stress and frustration due to readily available knowledge and expertise. Reduced stress and increased self-efficacy, optimism, hope, and resiliency.

Reduces stress caused by a lack of knowledge, skills, and competencies by ensuring continuous improvement in skills and competencies through various trainings to distinct levels of executives.

It reduces the ambiguity among ATSEP on their career and motivates them to progress in developing the competencies and qualities that are required for the career progression. Talented people remain engaged and be committed members of the organization as they are aware of the opportunities for career development and growth.

Feeling of accomplishment for educated graduate recruits who are given education and training for core technical or professional roles.

Gaps in the knowledge, skills and competencies is addressed through systematic workplace learning and planned experience. Reduced stress due to lack of knowledge, skills, and competencies, through various means of L & D, the gaps can be filled through self-directed learning. Motivated to improve their leadership and management skills toward the career progression. Motivated to assume higher responsibilities as they are developed with appropriate workplace learning and planned experience.

5.4. Actions by ANSP

Establishing ANSP level knowledge management system.

Talent planning - the process of determining how many and what types of talented individuals are required now and in the future. It employs workforce planning techniques.

Talent resourcing plans - the outcomes of talent planning are programmes for obtaining people from within and outside the organization (internal and external resourcing). Internally they involve the identification of talent, and their development and career management. Externally, they refer to the implementation of policies aimed at attracting high-quality workers.

Talent development - learning and development policies and programmes are key components of talent management. They aim to ensure that people acquire and enhance the skills and competencies they need. Policies should be formulated by reference to 'employee success profiles,' which are described in terms of competencies and define the qualities that need to be developed.

The talent pipeline – the processes of resourcing, talent development and career planning that maintain the flow of talent needed to create the talent pool required by the organization.

Integrate learning and development plans and programs with the safety and service strategy and human resource strategy. Designing the learning and development programs as performance related, to achieve specified improvements in corporate, functional, team and individual performance and make a major contribution to bottom-line results. Framework for individual learning through self-managed learning and are supported by coaching, mentoring and formal training. Ensuring the blend of learning through workplace learning and planned experience so that required knowledge, skills and competencies are addressed without gaps.

5.5. Actions by ATSEP

Making use of the opportunities given for learning and developing the skills and competencies. Investing time on knowledge update in the required areas. Discussing with the senior colleagues and clarifying the doubts.

Organizing the unique knowledge gathered. Sharing the unique knowledge to others. Contributing for the knowledge management.

Self-directed learning to improve performance in their present job or to develop their potential and satisfy their career aspirations. Develop leadership skills as well as management skills to progress in the career. Prepare to assume higher responsibilities through workplace learning and planned experience.

5.6. Most Influential Countermeasures

By providing only optimum number of verified and validated SOPs without redundancy, the stress of restoring facilities in brief time, will reduce significantly.

ANSP level scientific knowledge management on operations, maintenance, projects, and emergencies will reduce the stress significantly as ATSEP are continuously learning the latest problems and solutions and be ready with the proven techniques.

5.7. Human Factors Issues Addressed

5.7.1. Directly Addressed Factors

1	Different make and model for each facility / system.
2	Frequent failures of OFC and leased lines connectivity. Non availability of near perfect cable or line diagrams for optical fibre cable and power lines in the operational area.
3	Impact of changes not communicated, and individuals are reluctant to adopt.
4	Improper Complaint reporting mechanism by user, which do not convey the key information required for the early rectification of the equipment.
5	Improper training (Training, assessing and evaluation) for the required competencies. There is a gap in the training provided and the practical work environment.
6	In compatible interfaces and data formats among different makes and models for integration and extending the data and voice to other ACC or APP airports.
7	Inaccurate procedures, lack of tested and validated SOPs leads to corrective maintenance delays.
8	Lack of brainstorming on handling unfamiliar situation and regular interactions for knowledge sharing.
9	Lack of document control and missing acknowledgement on new update on regulations and operational procedures.
10	Lack of effective annual spare and capital procurement plan and related budget provisions.
11	Lack of effective coordination procedures for men material movements inside the operational areas of private operator owned airports.
12	Lack of external training, workshops, and seminars to keeping up-to-date knowledge on modern technology and systems well before the systems getting inducted.
13	Lack of knowledge and expert support while trying to fix an unfamiliar technical glitch.
14	Lack of knowledge in handling emergencies and disastrous situations.
15	Lack of knowledge on critical maintenance aspects of the equipment outsourced.
16	Lack of knowledge sharing on latest developments in local airport level and in ANSP level to frontline ATSEP.
17	Lack of KS and Competency to manage complex modern equipment.
18	Lack of operational training to develop competency on the old generation equipment even after service life expansion program in place.
19	Lack of opportunity to develop expertise on networking, operating systems, cyber security, project management etc. due to lack of in-house expertise instructors and training infrastructure.

20	Lack of self-learning tools
21	Lack of teamwork, more dependency on individuals and collective inputs not taken by team lead for decision.
22	Lack of training and documentation increases workload and time.
23	Lack of update in the maintenance procedures, operating procedures, and maintenance philosophies in line with the technologies.
24	Mismatching in course development that does not make the ATSEP competent enough to address the practical field issues.
25	No clear demarcation of competencies so spending more time on KSC update on all areas without even having the access to the equipment and facilities. (Too many make and models)
26	Poor OEM documentation on system, diagnostic procedures, site adaptable parameters and on HMI.
27	Procedural delays and extended file works on spare procurements.
28	Requirement of diversified expertise (Cyber security, Information technology, interface devices, data convertors, communication lines and links) other than core equipment for maintaining the service level.
29	Short of ideas; being alone.
30	Sudden failures of the systems due to natural calamities and power supply issues.
31	Unable to resolve external interference problems and other typical problems not covered in the training.

5.7.2. Indirectly Addressed Factors

1	Additional tasks assigned by regional and or corporate head quarter in addition to local airport works. (QR preparation, tender evaluation, course development, etc..)
2	Always under pressure to give back the facilities within the EST of NOTAM
3	Project management.
4	Contract management.
5	Fear on consequences of failure while trouble shooting in live system.
6	Inadequate first-hand information given by user.
7	Constant mind switchover between old and modern technologies, procedures, tools etc., within the same service facilities. Different aged, make and model of equipment within a single service facility like VHF, Nav-Aids, and surveillance.
8	Expectations on making quick decision, in less reactive time with zero error tolerance and on fixing the system immediately.
9	Extraordinary file work delays in getting approvals for proceeding to next stages.
10	Forced to do tasks even without qualification (attending power lines of UPS and working at heights etc..)
11	Frequent failures and outages of out-lived equipment and facilities.
12	Lack of guidelines and provisions of PPE to ATSEP for protecting them while working at highly polluted with noise and dust, heights, closer to high power radiating radars, X-rays, etc.,
13	Lack of opportunity for developing and or retaining core competencies due to deployment in non-core areas for a prolonged period before and after equipment training.
14	Lack of project management skills and competencies at the same time, simultaneous operation and projects tasks given with unrealistic timelines.
15	Lack of protection and guidelines while attending equipment during heavy lightning and abnormal weather conditions.

16	Little or no-hands on training
17	Manhours spent in Cargo, Customs clearance, without proper expertise or supporting staff instead of spending time on critical maintenance works and project works.
18	Repairing critical modules of the facilities that are under NOTAM
19	Sense of expectation on out-lived equipment failures even while conducting preventive maintenance.
20	Trouble shooting in busy working environment on live interconnected systems.
21	Unrealistic timelines due to poor planning and coordination with ATCOs before making maintenance activities.
22	User requirements defined not met with the supplied system.

5.8. Self-Evaluation Checklist

5.8.1. Self-Evaluation Checklist for ANSP

Human performance management processes maturity level Self-Evaluation Check list for ANSP – KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Knowledge management, talent management, learning and development for directly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria.	

2)	Knowledge management, talent management, learning and development for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	
		Level B	
		Level C	
		Level D	
		Level E	
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation	
4)	If maturity level is D w.r.t score of (1)		
	Have you established organizational knowledge management?		Y/N
	Have you managed talent management to match with the strategic people resourcing?		Y/N
	Have you established learning and development system for individuals as well as teams?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>		
5)	If maturity level is E w.r.t score of (1)		
	Did you bring new knowledges in the knowledge management in the last year?		Y/N
	Did you bring any changes in the talent planning to suit the safety and service strategy in last two years?		Y/N
	Did you evaluate the effectiveness of the learning and development process in last year?		Y/N
	Have you set the key performing indicators for measuring the above?		Y/N
<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>			
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>			

5.8.2. Self-Evaluation Checklist for ATSEP

Human performance management processes maturity level Self-Evaluation Check list for ATSEP – KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood the opportunities for my career development and growth.			Y/N
	B	I know the provisions for developing myself to core technical or professional roles			Y/N
	C	I have developed the leadership and management skills toward the career progression			Y/N
2)	If your choice for one or more questions is “N,” please state the specific reasons				
	A				
	B				
	C				

5.9. Resilience and Cost Benefits

These actions have a negligible budgetary impact on the ANSP, which has well-established information technology and training infrastructure. Initial man-hours spent designing systems with available infrastructure will yield exceptionally good long-term results. These efforts will reduce the costs of corrective maintenance and lost opportunities during breakdowns. It also reduces the time required for all tasks, saving money in terms of man-hours. Long-term strategies and valuable human capital benefit ANSP.

5.10. Other Countermeasures

By ensuring necessary OEM documentation and support on spare that suits the maintenance philosophies of the ANSP, overall effectiveness of corrective maintenance will improve.

Provisioning online based self-learning tools.

Conducting seminar on best practices adopted at different airports within ANSP.

5.11. Relevant Appendix

To understand the available ICAO framework, adoption hurdles, and how to overcome those roadblocks, please refer to Appendix 6 - Progressive Training.

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CHAPTER 6 INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY

This chapter emphasizes how strategic maintenance of CNS/ATM facilities can help ANSPs to generate more revenue through adaptive innovation and optimal usage of resources.

THE OBJECTIVE

Benefits include improved stakeholder relations, reduced reactive maintenance costs, and predictive maintenance capabilities.

ANSPs should implement an integrated best practice maintenance strategy that includes preventive, predictive, and reliability-centred maintenance, among other practices.

ATSEP should plan and undertake maintenance tasks, maintain records, and propose new procedures. The most influential countermeasures are reviewing maintenance philosophies, utilizing technologies, and implementing proactive procurement and replacement policies.

“Within a complex system, it is the human contribution that often provides the important safety barriers and source of recovery.”

DOC 10151 -MANUAL ON HUMAN PERFORMANCE

6. INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY

6.1. Introduction

Strategic maintenance increases profits of ANSP by increasing the availability of all the CNS/ATM facilities in fullest functional capabilities for which they are designed. Maintenance strategies with adaptive innovation also contributes to overall reduction of costs through optimum usage of men, materials, contracts, and energy.

6.2. Benefits to ANSP

Ensures trust relations with all the stakeholders, especially outside ANSP. Effective preventive maintenance reduces the costs due to reactive maintenance even reducing their occurrences. Strategic maintenance reduces costs due to optimum spares on inventory. ANSP has data for financial optimization decisions like whether to repair in-house or repair or replace. ANSP has the significant capability of increasing the service life of the equipment which directly adds to the cost benefits of ANSP. ANSP will be able to establish the system for predictive maintenance to prevent reactive maintenance.

6.3. Benefits to ATSEP

Feel recognized as key role player in the organization and motivated to develop knowledge, skills, and competencies to meet the performance requirements. Reduced stress due to availability of documentation from original equipment manufacturers for additional references and improvisation. Get better coordination results from the stakeholders on carrying planned maintenance.

6.4. Actions by ANSP

The maintenance strategy shall drive the ANSP for an integrated best practice that includes preventive maintenance, inventory and procurement, workflow and controls, computerized maintenance management system usage, stakeholders' involvement, predictive maintenance, reliability centred maintenance and total productive maintenance.

The preventive maintenance (PM) program is the key to any attempt to improve the maintenance process. This program reduces the amount of reactive maintenance to a level that allows the other practices in the maintenance process to be effective. Effective preventive maintenance reduces the costs due to reactive maintenances even reducing their occurrences.

Proactive measures before the induction of new systems to ensure the resources and competencies are made available before the installation of new systems. Involving the filed level experts in the major system procurements from the preparations of the specifications preparations till commissioning including factory acceptance, site acceptance, and OEM document verifications.

Ensuring the OEM documentation on recommended maintenance procedures and detailed technical and operation manuals in line with the maintenance philosophies of the ANSP. Before the ANSP progress to next level of process improvisation, the initial preventive maintenance begins only with the OEM documentation. Any gap in this will severely impact the fundamental resilience of the ANSP that is preventative control. Most important resilience level is to keep all the stakeholders outside the ANSP trust. Also, ANSP will fail to meet the regulatory requirements.

Ensuring required tools, knowledge, skills, and competencies are available with the field level ATSEP for carrying out the maintenance effectively.

All the maintenance activities should be documented for traceability from initiation to completion. This documentation helps in the effective planning and scheduling of future proactive maintenance schedules. Computerization of these data flow will help the ANSP for processing and analysing for process improvisation. Computerized data analysis that includes downtime, maintenance cost, duration of the degraded mode of operations, etc., will guide to financial optimization to decide whether to repair or replace the system. This will also give ANSP the key data for the service life expansion program.

Established stakeholders' agreement on owning the maintenance activities as a common task and all planned activities are carried out in time to save cost on reactive maintenance tasks. The entire stakeholders should be aware of the system capability, performance, and the importance of maintenance activities.

Carrying the flight calibration as required in time to ensure the safety certification as well as to prevent the increased man-hours on additional ground checks.

Innovated means of observations and data logging through technologies for automated investigation of equipment without disturbing the operation, reduces man-hours spent on traveling to remote sites, carrying out routine activities, and gives data for predictive maintenance.

Continuous improvement on maintenance philosophies, as well as training and development of the ATSEP in accordance with the reviewed maintenance philosophies, must be done on a regular basis to ensure safety and cost savings. Internal or external benchmarking with key performance indicators will propel the organisation to higher levels of maturity.

6.5. Actions by ATSEP

Planning and undertaking scheduled maintenance tasks. Responding to breakdowns, diagnosing faults, repairing, and restoring the facilities. Maintain all the records of maintenance including the cost involved. Initiate root cause analysis on repeated faults to understand the primary and secondary failures. Planning for the annual spare and other maintenance material required, provision the budget needed, and stock the optimum spares. Propose new and improvised maintenance procedures for approval. Ensuring the health and safety regulatory requirements. Adhering to standard operating procedures and all coordination procedures.

6.6. Most Influential Countermeasures

Reviewing maintenance philosophies, utilizing technologies, and bringing innovation to supervise CNS/ATM systems for reducing paper works, physical visits and saving manhours.

Pro-active procurement and replacement policies in managing the out-lived equipment will reduce the stress among the key stake holders of ANSP due to their safety commitment.

6.7. Human Factors Issues Addressed

6.7.1. Directly Addressed Factors

1	Being helpless in rectifying the unit after knowing inherent flaws in the design of the equipment and its unreliability
2	Compromising qualities, essential OEM documentations, training and after acquisition supports on new systems against the cost (L1).
3	Continuous changes in the scope and requirements on complex projects from the user point of view, without proper consideration from the maintenance point of view.
4	Delayed annual and other planned preventive and corrective maintenance due to non-availability of time for maintenance actions.
5	Delayed flight calibration due to poor preparation and planning.
6	Faulty equipment design and or faulty alert mechanism. Mis-leading front panel indications and irrelevant documentations. Unknown bug and or hidden deficiencies cropping up after the warranty and service agreement.
7	Frequent failures and outages of out-lived equipment and facilities.
8	Improper Complaint reporting mechanism by user, which do not convey the key information required for the early rectification of the equipment.
9	Lack of effective annual spare and capital procurement plan and related budget provisions.
10	Lack of readily available spare parts and poor supply chain management makes the recovery delays after emergencies and disasters.
11	Lack of update in the maintenance procedures, operating procedures, and maintenance philosophies in line with the technologies.
12	Non availability of calibrated working test equipment as required for the preventive as well as for the corrective maintenance.
13	Non availability of vehicle to reach the remote site.
14	Non-utilization of technologies and machines for the installation and maintenance works and planning.
15	Often project deadlines are set without freezing the scopes and augmenting with necessary resources.
16	Planning (for replacement of obsolete system) and procurement.
17	Poor OEM documentation on system, diagnostic procedures, site adaptable parameters and on HMI.
18	There is a long wait and no provision of comfortable and appropriate mode of commute to approach remote sites even though during scorching summer days.
19	Too much of file works for a low-cost but immediate and essential spare procurement.
20	User requirements defined not met with the supplied system.
21	Too many additional facilities added into ANSP like RADARS, CNS/ATM automation facilities, Nav-Aids at new airports and new RWYs in the last decade, without augmenting the human and other resources.

6.7.2. Indirectly Addressed Factors

1	Approval of projects without looking into the resource's requirements like human, vehicles, and other support. Workload increases on coordinating for essential supporting resources and prevents the concentration on core project activities as well as to skip the maintenance activities of ongoing operational facilities.

2	Constant mind switchover between old and modern technologies, procedures, tools etc., within the same service facilities. Different aged, make and model of equipment within a single service facility like VHF, Nav-Aids, and surveillance.
3	Frequent (change of) exposure to too low temperature in the server or equipment room and too high outside temperature.
4	Frequent exposure of high outside remote site temperature and less inside equipment room temperature in a shift.
5	Frequent failures of OFC and leased lines connectivity. Non availability of near perfect cable or line diagrams for OFCs and power lines in the operational area.
6	Installations at very remote places, and high mountains preventing regular visits due to resources.
7	Lack of guidelines and provisions of PPE to ATSEP for protecting them while working at highly polluted with noise and dust, heights, closer to high power radiating radars, X-rays, etc.,
8	Lack of protection and guidelines while attending equipment during heavy lightning and abnormal weather conditions.
9	Managing the procurement tasks and maintenance tasks of multiple airports in addition to the local.
10	Procedural delays and extended file works on spare procurements.
11	Age and condition of supporting equipment like generators, electrical installations, air conditioners etc.,
12	Annual plan for ATSEP training and development in line with the operational and competency requirements.
13	Different make and model for each facility / system.
14	Difficulties in trouble shooting behind the ATC consoles in general and at late night hours due to poor lighting at the behind the console.
15	Extraordinary file work delays in getting approvals for proceeding to next stages.
16	Fear on consequences of failure while trouble shooting in live system.
17	Frequent movement to and from in between ATC complex and different operational sites especially in case of A-SMGCS, ILS sites and multiple RADAR sites for daily checks and maintenance work.
18	In compatible interfaces and data formats among different makes and models for integration and extending the data and voice to other ACC or APP airports.
19	Inadequate first-hand information given by user.
20	Insufficient logistics support and communication infrastructure to support ATSEP works, those at remote site/area.
21	Mismatching in course development that does not make the ATSEP competent enough to address the practical field issues.
22	Narrow space around equipment racks filled with too many wires and connections, making difficulties in accessing and replacing the modules.
23	No access of fresh air and sunlight for long duration.
24	Permanent combined duties due to shortage of manpower increases workload and reduces the attention in all the combined units.
25	Repairing critical modules of the facilities that are under NOTAM
26	Sense of expectation on out-lived equipment failures even while conducting preventive maintenance.
27	Single man shift.
28	Trouble shooting in busy working environment on live interconnected systems.

6.8. Self-evaluation checklist

6.8.1. Self-evaluation checklist for ANSP

Human performance management processes maturity level				
Self-Evaluation Check list for ANSP – INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Induction of new systems and maintenance philosophy for directly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria	
2)	Induction of new systems and maintenance philosophy for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A		
		Level B		
		Level C		
		Level D		
		Level E		
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation		
4)	If maturity level is D w.r.t score of (1)			
	Maintenance strategy includes all the process in addition to preventive maintenance			Y/N
	All the maintenance activities are documented for easy traceability			Y/N
	Annual reactive maintenance duration is only 20% or less than the total maintenance duration?			Y/N
	Required competencies and resources made available prior to the installation of new systems.			Y/N
	All OEM documents required to meet the maintenance strategies were ensured before SAT			Y/N
	Computer-based maintenance data analysis established for financial optimization			Y/N
	Root cause analysis is being practiced on safety sensitive facilities for finding primary failures			Y/N
	If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.			

5)	If maturity level is E w.r.t score of (1)		
	Innovated means of observations and data logging done for automated investigation		Y/N
	Continuous improvement on maintenance process including training done as per new systems		Y/N
	Annual reactive maintenance cost is reduced when compared to last year		Y/N
	Computer based maintenance data analysis helped in carrying out predictive maintenance		Y/N
	Repeated failures were analysed through root cause failure and identified primary failures		Y/N
	Trained and developed ATSEP on FAT, SAT, and document verification to ensure OEM documents and system delivered as per the user requirements.		Y/N
	Have you set the key performing indicators for measuring the above?		Y/N
<i>If your score is one or more "N," please assume the immediate lower level of maturity and evaluate</i>			
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>			

6.8.2. Self-evaluation checklist for ATSEP

Human performance management processes maturity level					
Self-Evaluation Check list for ATSEP – INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood all the process involved in the maintenance strategy of my ANSP			Y/N
	B	I have well documented all the activities of maintenance for easy traceability			Y/N
	C	I have acquired all the skills and competencies required for maintaining new systems			Y/N
	D	I have acquired the skills for carrying root cause failure analysis			Y/N
	E	I have made the annual plan for the spares and other materials including budgeting			Y/N
2)	If your choice for one or more questions is “N,” please state the specific reasons				
	A				
	B				
	C				
	D				
	E				

6.9. Resilience and Cost Benefits

These actions are very essential for any ANSP as this is the lowest level of resilience any organizations to possess to retain the trust of the stakeholders and to meet the regulatory requirements. With effective preventive or proactive maintenances, reactive maintenance and its cost will come down to a greater extent. With innovation in carrying out the routine maintenance activities ANSP can reduce the costs of maintenance activities. With the systematic capture and analysis of the maintenance data ANSP can take financially optimized decisions like service life expansion instead of replacement.

6.10. Other Countermeasures

Pre-planning the pre-monsoon, annual and other major preventive maintenance tasks well in advance and carrying out the tasks as planned. So that sudden or total failures and long corrective maintenance works prevented.

Roadblocks on procurement process can be reduced by training selected ATSEP on government compliance requirements by experts having background on the financial regulation. ATSEP those who participate in the major or repeated procurement process can be permitted to have consultants on these areas.

Adopting procurement policies that facilitates buying quality systems.

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CHAPTER 7

WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD

This chapter discusses the importance of creating a positive work environment that promotes well-being and high performance in the aviation industry

THE OBJECTIVE

It emphasizes the value of reward and performance management in attaining these objectives as well as the advantages for both ANSPs (air navigation service providers) and ATSEPs (air traffic safety electronics employees).

It makes suggestions for steps ANSP and ATSEP can do to establish a great working environment, including developing incentive policies and practices, delivering assistance and direction for performance development, and implementing non-monetary benefits.

“People’s ability to adapt means that the system is more likely to recover from unexpected disturbances, resulting in increased resilience.”

DOC 10151 -MANUAL ON HUMAN PERFORMANCE

7. WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD

7.1. Introduction

The work environment consists of the system of work, the design of jobs, working conditions and the ways in which people are treated at work by their managers and co-workers. Working conditions need to meet health and safety requirements. The way people are treated is affected by managerial behaviour, achieving work-life balance and how issues such as stress, harassment and bullying are dealt with.

Well-being at work exists when people are happy with what they do, how they are treated, how they get on with others. The well-being of employees depends on the quality of working life provided by their employers the feelings of satisfaction and happiness arising from the work itself and the work environment.

Performance management and reward management are strongly associated topics that play an important part in achieving one of the key goals of HRM – to contribute to the development of a high-performance culture.

Performance management is a means of getting better results by providing the means for individuals to perform well within an agreed framework of planned goals, standards, and competency requirements. It entails developing a shared understanding of what is to be accomplished and how it is to be accomplished.

Performance management, if carried out properly, can reward people by recognition through feedback, the provision of opportunities to achieve, the scope to develop skills, and guidance on career paths. All these are non-financial rewards that can encourage job and organizational engagement and make a longer-lasting and more powerful impact than financial rewards such as performance-related pay.

Reward strategy defines what how an organization wants intends to do about to reward their employees. It leads to the development of a reward system that consists of interrelated processes and practices that combine to ensure that reward management is carried out to the benefit of the organization and its employees.

7.2. Benefits to ANSP

Increased job satisfaction and happiness among the workforces. Development towards a high-performance culture. Getting better results from all. Increased level of engagement among the workforces. Talented people are attracted and retained.

7.3. Benefits to ATSEP

A set of properties of the work environment, perceived directly or indirectly by the employees, which is assumed to be a major force in influencing employee behaviour. Engagement and commitment strategies may be more about taking action that affects employees collectively such as improvements in the work environment.

A satisfactory work environment leads to reduced stress, improves work-life balance, eliminates sexual harassment and bullying problems, providing services for individuals including employee assistance programmes, and provides individual.

services such as employee assistance programmes and provides group services such as restaurants and social/sporting facilities.

They include non-monetary recognition of accomplishments, the creation of fulfilling jobs, providing opportunities for people to advance their skills and careers, and providing a work environment that promotes a high quality of life at work and an appropriate balance of work and personal life (work-life balance).

7.4. Actions by ANSP

Employers are responsible for creating an excellent work environment, not only because it is their duty to do so but also as part of the total reward system. Total reward approaches that emphasize the importance of enhancing the work environment.

ANSP need to create a work environment that is conducive to high performance and can introduce policies and practices that encourage people to do everything expected of them.

Performance management provides the basis for self-development but, importantly, it is also about ensuring that the support and guidance people need to develop and improve are readily available. Performance management can play a significant role in rewarding employees by providing them with positive feedback and the recognition of their accomplishments.

Developing reward policies and practices that support the achievement of safety and service goals. Rewarding people according to their contribution. Recognizing the value of everyone who is making an effective contribution, not just the exceptional performers. Providing incentives that attract and retain employees and contribute to the development of a high-performance culture.

Creating non-monetary rewards focuses on the varying degrees of recognition, achievement, personal growth, and acceptable working conditions that people have. Non-monetary rewards can be extrinsic, such as praise or recognition, or intrinsic, such as job challenge and interest, as well as feelings that one's work is worthwhile.

7.5. Actions by ATSEP

Perform well in an excellent work environment. Develop on the required area based on the performance management feedback by utilizing readily available support and guidance.

7.6. Most Influential Countermeasures

Providing a working environment, with consideration to human factor issues of ATSEP.

Following HR policies that encourage recognition, appreciation, and suitable compensations.

7.7. Human Factors Issues Addressed

7.7.1. Directly Addressed Factors

1	ATSEP desire for recognition on all the facilities (CNS/ATM Automation) and on different makes and models.
2	Behind the curtain profession
3	Below par and uncomfortable residential facilities at faraway places instead of provisions of comfortable nearby quarters with reasonable rent.

4	Congested or no desk / table. Too many items placed in the control and monitoring room. No space for keeping important manuals, procedures, SOPs in most visible and accessible manner.
5	Continuous works including weekends during the demanding situations for meeting the special maintenance and project works along with routine operational works.
6	Difficulties in trouble shooting behind the ATC consoles in general and at late night hours due to poor lighting at the behind the console.
7	Frontline ATSEP views ignored, and not recognized as experts.
8	Gender bias and equal field works not assigned to women ATSEP.
9	Insufficient logistics support and communication infrastructure to support ATSEP works, those at remote site/area.
10	Lack of attractive compensation for extra shift works performed
11	Lack of basic workplace facilities like parking, canteen, fixtures, rest rooms, vending machines, common transport for pickup and drop from employee quarters to workplace, etc.,
12	Lack of guidelines and provisions of PPE to ATSEP for protecting them while working at highly polluted with noise and dust, heights, closer to high power radiating radars, X-rays, etc.,
13	Lack of motivating compensations for extra manhours spent in general maintenance, VVIP movements, project works, additional works, and additional shifts.
14	Lack of opportunity and fund provisions for innovation and carry station level smaller projects.
15	Lack of pride as not recognized as expert in particular field and transferred anywhere without considering the competencies acquired.
16	Lack of protection and guidelines while attending equipment during heavy lightning and abnormal weather conditions.
17	Lack of scientific annual performance assessment and rewarding scheme considering the unique working environment and expected level of performance of ATSEP.
18	Lack of specific workplace facilities for women like identified rest rooms in the operational areas, Creche, childcare leave, etc...,
19	Lack of time to family
20	Lack policies and practices towards the human factors of ATSEP.
21	Narrow space around equipment racks filled with too many wires and connections, making difficulties in accessing and replacing the modules.
22	No access of fresh air and sunlight for long duration.
23	No refreshment breaks
24	No say of ATSEP in HR policies being set for them.
25	No standardized duty pattern, duration, breaks and rest periods
26	Odd hours and on field shift duties for women ATSEP without basic rest room facilities in the operational sites.
27	Payment delays.
28	Salary and allowances not at par with the industry standards for the level of stress and workload.
29	Sense of being unheard by management
30	Sleep loss due to irregular shift pattern or fast rotating shift pattern
31	Stress and fatigue management.
32	Stressful 12 hours night shift without breaks and rests

33	There is a long wait and no provision of comfortable and appropriate mode of commute to approach remote sites even though during scorching summer days.
34	Working in lower temperature in equipment room.
35	Working under noise pollution in the airfield.
36	Working under severe dust pollution during the project work.
37	Acceptance of inefficient manpower by management without any mitigation.
38	Improper and unbalanced work distribution with undue over burden and undue over leniency.
39	Lack of support on career development and career plan.
40	No clear OFFs before shift pattern changes

7.7.2. Indirectly Addressed Factors

1	Compulsory movements within the nation during service life
2	Lack of involvements in the discussion sessions and feedback sessions on major policy decisions.
3	Lack of involvements of frontline experts in policies designed for improving the performance of frontline experts.
4	Annual plan for ATSEP training and development in line with the operational and competency requirements.
5	Approval of projects without looking into the resource's requirements like human, vehicles, and other support. Workload increases on coordinating for essential supporting resources and prevents the concentration on core project activities as well as to skip the maintenance activities of ongoing operational facilities.
6	Difference in stated corporate Mission/Vision and the ground reality.
7	Extra shift duties are forced due to shortage of manpower
8	Forced to carryout major maintenance works only during late night and need to return to duty next day by 0930AM.
9	Frequent (change of) exposure to too low temperature in the server or equipment room and too high outside temperature.
10	Frequent exposure of high outside remote site temperature and less inside equipment room temperature in a shift.
11	Frequent movement to and from in between ATC complex and different operational sites especially in case of A-SMGCS, ILS sites and multiple RADAR sites for daily checks and maintenance work.
12	Inhibition of valuable suggestions and ideas due to the overload of works.
13	Innumerable, unspecified, and unpredicted works assigned to selected ATSEP preventing their attention from core maintenance tasks.
14	Installations at very remote places, and high mountains preventing regular visits due to resources.
15	Irregular duty calls without any pattern due to shortage of manpower
16	Lack of effective coordination procedures for men material movements inside the operational areas of private operator owned airports.
17	Lack of knowledge in handling emergencies and disastrous situations.
18	Late hour calls and frequent calls after duty hours even during weekly OFFs
19	Leave requests not approved
20	Mandatory transfers
21	Monotonous monitoring for a long time.

22	Mostly corrective maintenance work conducted at night.
23	Multiple jobs of diversified nature in quick successions without notice or planning.
24	Must report again by 0930AM even after late night breakdown calls and late-night project works.
25	Non availability of calibrated working test equipment as required for the preventive as well as for the corrective maintenance.
26	Non availability of vehicle to reach the remote site.
27	Permanent combined duties due to shortage of manpower increases workload and reduces the attention in all the combined units.
28	Short of ideas; being alone.
29	Simultaneous project supervision and maintenance activities without additional manpower.
30	Single man shift.
31	Too many unclassified additional works in smaller airports. Essential maintenance tasks skipped.
32	Travelling long distance from home to workplace as green field airports are situated at outer part of the cities and no provision of common transportation facility.
33	Uncertainty on future roles and responsibilities.
34	Where there is electronics, there shall be an ATSEP – Belief of airport in-charges.

7.8. Self-Evaluation Checklist

7.8.1. Self-Evaluation Checklist For ANSP

Human performance management processes maturity level Self-Evaluation Check list for ANSP – WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Work environment, well-being, performance, and reward for directly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria.	

2)	Induction of new systems and maintenance philosophy for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	
		Level B	
		Level C	
		Level D	
		Level E	
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation	
4)	If maturity level is D w.r.t score of (1)		
	Total reward system approaches in practice that emphasize the enhanced work environment.		Y/N
	Work environment is conducive to high performance.		Y/N
	Performance management system in practice ensures the support and guidance people need to develop and improve are readily available.		Y/N
	Reward system includes non-financial rewards like recognition, achievement, personal growth		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>		
	If maturity level is E w.r.t score of (1)		
5)	Work environment is periodically reviewed for enhancement		Y/N
	Increased level of job satisfaction and happiness found after enhancing work environment		Y/N
	Unique values added by all the employees were recognized and rewarded		Y/N
	Increased level of engagement among the workforces were observed		Y/N
	Have you set the key performing indicators for measuring the above?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>		
	<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>		

7.8.2. Self-Evaluation Checklist for ATSEP

Human performance management processes maturity level Self-Evaluation Check list for ATSEP – WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	Work environment enabled me towards more engagement and commitment.			Y/N
	B	Work environment has reduced my stress and improved my work-life balance			Y/N
	C	I have not experienced or heard of any sexual harassment and bullying problems.			Y/N
	D	I am benefited by the individual as well as group services provide by my ANSP			Y/N
	E	I am highly motivated due to the non-financial reward systems in place.			Y/N
2)	<i>If your choice for one or more questions is “N,” please state the specific reasons</i>				
	A				
	B				

	C	
	D	

7.9. Resilience And Cost Benefits

ANSP incurs minimal costs in improving the work environment and incurs no additional costs in implementing non-monetary rewards. Organizations progress toward high performance by increasing employee job satisfaction and happiness. Talent management objectives are met when talented people are attracted and retained, and employee behaviour and organisational culture are improved.

7.10. Relevant Appendix

Refer to Appendix 4 on ATSEP Duty Time Limitation for further information on the current system of watch hours, shift duty cycles, duty hours in a day, number of duties per week, number of hours of duty per week, impact, and advice for better management of duty cycles and duty hours.

To comprehend the dread psychosis behind Covid-19, mitigation measures, and future action in similar circumstances, please refer to Appendix - 5 Measures During Pandemic.

To understand the three stages of stress, stressors in the workplace, the effects of stress, and the concepts of stress management, please refer to Appendix 7: Stress Management.

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CHAPTER 8 MOTIVATION, COMMITMENT & ENGAGEMENT

This chapter discusses the importance of motivation, commitment, and engagement which are the factors that influence performance.

THE OBJECTIVE

Intrinsic motivation is when people find their work important, interesting, and challenging, and have autonomy, opportunities to achieve and advance, and opportunities to use and develop their skills and abilities.

Extrinsic motivation involves rewards or punishments to motivate people. Commitment and engagement are linked and influenced by factors such as training, career opportunities, performance appraisal systems, autonomy, and rewards and recognition.

High performance is achieved through motivated, committed, and engaged employees. ANSP and ATSEP can benefit from increased motivation, commitment, and engagement.

“The overall goal of Aviation Maintenance human factors research is to identify and optimize the factors that affect human performance in maintenance and inspection.”

- FAA on Human Factors in Aviation Maintenance

8. MOTIVATION, COMMITMENT, AND ENGAGEMENT

8.1. Introduction

Motivation, commitment, and engagement are all factors that influence behaviour and thus performance. Motivation is the driving force that propels, directs, and sustains behaviour. Well-motivated people who are willing to exert discretionary effort, i.e., do more than is expected of them, achieve high performance.

Intrinsic motivation occurs when people believe that their work is important, interesting, and challenging, and that it gives them a reasonable degree of autonomy (freedom to act), opportunities to achieve and advance, and opportunities to use and develop their skills and abilities. It can be described as work-motivation. Job design can help to boost intrinsic motivation.

Extrinsic motivation occurs when things are done to or for people to motivate them. These include rewards such as incentives, increased pay, praise, or promotion; and punishments such as disciplinary action, withholding pay, or criticism. Extrinsic motivators can have an immediate and powerful effect, but it will not necessarily last long.

The intrinsic motivators, which are concerned with the ‘quality of working life,’ are likely to have a deeper and longer-term effect because they are inherent in individuals.

Commitment represents the strength of an individual’s identification with, and involvement in, an organization. Commitment refers to attachment and loyalty.

Engagement takes place when people are committed to their work and the organization and are motivated to achieve elevated levels of performance.

Both commitment and engagement are inextricably linked. Some of the factors that influence commitment and engagement are training, career opportunities, performance appraisal systems, autonomy, and rewards and recognition.

8.2. Benefits to ANSP

High performance is achieved through highly motivated, committed, and engaged employees. All the benefits discussed in previous chapters where high performance is discussed apply here as well.

8.3. Benefits to ATSEP

Motivated to contribute more through increased commitment and engagement. All the benefits discussed in previous chapters where high performance is discussed apply here as well.

8.4. Actions by ANSP

Keeping the motivation level high through both intrinsic as well extrinsic measures. Provide additional training to the people in their areas of interest. Provide career opportunities based on their performance which is evaluated through a scientific performance evaluation system. Provide autonomy to the workforce according to their position in the organization.

8.5. Actions by ATSEP

Making use of the training opportunities to add the knowledge in the areas of interest or where there is a need or where there is a gap. Efficient and contributing ATSEP are recognized through intrinsic measures and at the same time all contributions are taken care by extrinsic means.

8.6. Most Influential Countermeasure

All the countermeasures discussed in the earlier topics will also enhance the motivation, commitment, and engagement. However, additional countermeasures to consider are given in the end of this chapter.

8.7. Human Factors Issues Addressed

8.7.1. Collectively Addressed Factors

Considering all the influential countermeasures discussed so far, collectively the following factors are addressed that add stress and fatigue.

1	Acceptance of inefficient manpower by management without any mitigation.
2	ATSEP desire for recognition on all the facilities (CNS/ATM Automation) and on different makes and models.
3	Continuous changes in the scope and requirements on complex projects from the user point of view, without proper consideration from the maintenance point of view.
4	Frontline ATSEP views ignored, and not recognized as experts.
5	In compatible interfaces and data formats among different makes and models for integration and extending the data and voice to other ACC or APP airports.
6	Inhibition of valuable suggestions and ideas due to the overload of works.
7	Lack of attractive compensation for extra shift works performed
8	Lack of brainstorming on handling unfamiliar situation and regular interactions for knowledge sharing.
9	Lack of corrective measure in addressing the commitment levels and contributions of ATSEP.
10	Lack of effective annual spare and capital procurement plan and related budget provisions.
11	Lack of guidance, information exchange, and non-participation in the discussion make the freshers isolated.
12	Lack of involvements in the discussion sessions and feedback sessions on major policy decisions.
13	Lack of involvements of frontline experts in policies designed for improving the performance of frontline experts.
14	Lack of knowledge and expert support while trying to fix an unfamiliar technical glitch.
15	Lack of knowledge in handling emergencies and disaster situations.
16	Lack of motivating compensations for extra manhours spent in general maintenance, VVIP movements, project works, additional works, and additional shifts.
17	Lack of mutual respect and mentorship for knowledge and experience sharing among the generations.

18	Lack of opportunity and fund provisions for innovation and carry station level smaller projects.
19	Lack of pride as not recognized as expert in particular field and transferred anywhere without considering the competencies acquired.
20	Lack of scientific annual performance assessment and rewarding scheme considering the unique working environment and expected level of performance of ATSEP.
21	Lack of skills and competencies in managing the CNS/ATM automation systems (Configuration, adaptation, replacement and upgrading the network devices, operating systems, shared storage devices, firewalls, and device drivers etc..) due to lack of OEM documentations.
22	Lack of support on career development and career plan.
23	Lack of teamwork, more dependency on individuals and collective inputs not taken by team lead for decision.
24	Mismatching in course development that does not make the ATSEP competent enough to address the practical field issues.
25	Monotonous monitoring for a long time.
26	No clear job description, roles and responsibilities are varying after each movement, deployed at non-core areas.
27	No say of ATSEP in HR policies being set for them.
28	Non-utilization of technologies and machines for the installation and maintenance works and planning.
29	Peer pressure due to evaluation and comments from colleagues who are not accountable
30	Poor workload distribution makes few carries stress, pressure, fatigue, and timeline pressure throughout without any relief.
31	Salary and allowances not at par with the industry standards for the level of stress and workload.
32	Short of ideas; being alone.
33	Unable to resolve external interference problems and other typical problems not covered in the training.
34	Unrealistic timelines due to poor planning and coordination with ATCOs before making maintenance activities.

8.8. Resilience and Cost Benefits

Every cost and resilience benefit that we have previously addressed whenever high performance is mentioned also applies here.

8.9. Other Countermeasures

Encourage innovation on routine tasks.

Promote research groups within the ANSP.

Rewards and promotion based on contribution and effort.

Assign dedicated small assignments based on the specific talents and skills.

Innovative ideas should be welcomed through brainstorming sessions with the frontline experts before making major policies and procurements of new systems.

By limiting their stream of competency and developing higher level expertise and competencies, forming ANSP level backup team for emergency, disaster, and pandemic situation.



CHAPTER 9 BEHAVIOURAL AND ROLE SPECIFIC COMPETENCIES

This chapter discusses the importance of behavioural competencies (soft skills) and technical competencies (hard skills)

THE OBJECTIVE

Behavioural competencies relate to the desired behaviours needed for successful performance in areas such as teamwork, communication, leadership, and decision-making.

Technical competencies relate to the specific knowledge and skills required for job performance. The benefits and actions for ANSP and ATSEP regarding knowledge management, talent management, and learning and development are applicable to both.

The most influential countermeasure for ATSEP is to train them in human factors as per DOC 10057.

“Operator error is very rarely the root cause of an occurrence. Usually, some underlying systemic issue is hiding behind it.”

DOC 10151 -MANUAL ON HUMAN PERFORMANCE

9. BEHAVIOURAL AND ROLE SPECIFIC COMPETENCIES

9.1. Introduction

Behavioural competencies, also referred to as soft skills, specify behavioural expectations, i.e., the kind of behaviour needed to produce results under such topics as teamwork, communication, leadership, and decision-making. The focus on providing services to airlines and managing air traffic, awareness of developments in civil aviation, team orientation, results orientation, communication effectiveness, leadership, conflict resolution, innovation, adaptability, self-confidence and assertiveness, people management, planning and organising, technical skills, and decisiveness are a few examples of behavioural competencies.

Technical competencies—also referred to as "hard skills"—define what people must know and be able to accomplish (knowledge and skills) to carry out and satisfy performance objectives. They might relate to generic roles (sets of related roles) or to specific roles (referred to as "role-specific competences"). Typically, they are not included in a behavioural-based competency framework, even though they are connected when analysing and evaluating position needs and requirements.

9.2. Benefits to ANSP

All the benefits come out of knowledge management, talent management and learning and development are applicable here as well.

9.3. Benefits to ATSEP

All the benefits come out of knowledge management, talent management and learning and development are applicable here as well.

9.4. Actions by ANSP

All the actions discussed on knowledge management, talent management and learning and development are applicable here as well.

9.5. Actions by ATSEP

All the actions discussed on knowledge management, talent management and learning and development are applicable here as well.

9.6. Most Influential Countermeasures

Train ATSEP in human factors as per DOC 10057 in various levels that suits their technical and managerial accountabilities.

9.7. Human Factors Issues Addressed

9.7.1. Directly Addressed Factors.

1	24H operations with stringent regulatory compliance.

2	Expectations on making quick decision, in less reactive time with zero error tolerance and on fixing the system immediately.
3	Frequent changes in the team members or team lead prevents better teamwork and communications.
4	Lack of guidance, information exchange, and non-participation in the discussion make the freshers isolated.
5	Lack of involvements of frontline experts in policies designed for improving the performance of frontline experts.
6	Lack of knowledge and expert support while trying to fix an unfamiliar technical glitch.
7	Lack of knowledge in managing the available scarce human resources for maximum performance due to lack of soft skills.
8	Lack of leadership in building relationships and establishing communication or coordination frameworks with internal as well as external stakeholders.
9	Lack of leadership in communicating the priorities to sub-ordinates.
10	Lack of leadership in ensuring the safety conscious among sub-ordinate, instead of being reactive and blaming.
11	Lack of leadership in handling professional disagreement with internal and external stakeholders and pass it to frontline ATSEP.
12	Lack of leadership in managing conflicts and ensuring team goals and safety objectives over individuals interests and goals.
13	Lack of mutual respect and common values among internal stakeholders. (ATCOs, ATSEP, Engineers)
14	Lack of mutual respect and mentorship for knowledge and experience sharing among the generations.
15	Lack of teamwork, more dependency on individuals and collective inputs not taken by team lead for decision.
16	Managerial or higher responsibilities without proper training.
17	Peer pressure due to evaluation and comments from colleagues who are not accountable
18	Safety consciousness in keeping the facilities available all the time.
19	Sense of expectation on out-lived equipment failures even while conducting preventive maintenance.
20	Stress and fatigue management.
21	Timeline pressure from boss, management, ATCOs, and other stakeholders.

9.7.2. Indirectly Addressed Factors.

1	Always under pressure to give back the facilities within the EST of NOTAM
2	ATSEP desire for recognition on all the facilities (CNS/ATM Automation) and on different makes and models.
3	Being helpless in rectifying the unit after knowing inherent flaws in the design of the equipment and its unreliability
4	Constant mind switchover between old and modern technologies, procedures, tools etc., within the same service facilities. Different aged, make and model of equipment within a single service facility like VHF, Nav-Aids, and surveillance.
5	Improper and unbalanced work distribution with undue over burden and undue over leniency.

6	Improper training (Training, assessing and evaluation) for the required competencies. There is a gap in the training provided and the practical work environment.
7	Inhibition of valuable suggestions and ideas due to the overload of works.
8	Lack of effective coordination procedures for men material movements inside the operational areas of private operator owned airports.
9	Lack of knowledge in handling emergencies and disastrous situations.
10	Lack policies and practices towards the ATSEP of ATSEP.
11	Mostly corrective maintenance work conducted at night.
12	Poor workload distribution makes few carries stress, pressure, fatigue, and timeline pressure throughout without any relief.
13	Repairing critical modules of the facilities that are under NOTAM
14	Sudden failures of the systems due to natural calamities and power supply issues.
15	Unrealistic timelines due to poor planning and coordination with ATCOs before making maintenance activities.

9.8. Resilience And Cost Benefits

The knowledge management, people management, and learning and development benefits that increase resilience and lower costs are all applicable in this situation.

9.9. Other Countermeasures

Train ATSEP on the Engineering module as per DOC 10057 that suits the ANSP roles on projects and procurements.

Training on infrastructure as per DOC 10057.

Training on factory and site acceptance tests of major systems for verifying the performance of the system compliance of user requirements and tender terms and conditions.

Training on handling emergency and disaster situations.

Developing competency for preparing upcoming complex CNS/ATM systems specifications.

Developing Communication skills for effective communications with internal and external stakeholders.

Developing skills for preparing detailed project reports and technical reports.

Developing skills for analysing the external interference, external interfaces, data formats, communication protocol and communication links associated with CNS/ATM facilities.

Soft skill development to increase the productivity.

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CHAPTER 10

SAFETY CULTURE PROMOTION

In order to understand Safety culture promotion, we need to understand 'What culture means to different groups and sub-groups of people'. The culture of a group of people refers to their shared knowledge, experience, beliefs, values, attitudes, and meanings.

THE OBJECTIVE

Safety Culture is the way safety is perceived, valued, and prioritized in an organization.

ANSP and ATSEP both benefit from an optimum Safety Culture as it promotes mutual trust, enhances productivity, and leads to a clearer and more comprehensive picture of operational risk.

ANSP can take various actions to promote a positive Safety Culture, such as establishing better information flow, promoting strong safety values, and implementing Voluntary Safety Reporting Programs.

ATSEP should consider the potential effect of their decisions on safety and report any concerns voluntarily. The most influential countermeasure is to sensitize all stakeholders on the role of ATSEP in ATM service delivery and their contributions to air safety.

“Error is intimately bound up with the notion of intention. The term ‘error’ can only be meaningfully applied to planned actions that fail to achieve their desired consequences.”

- James Reason

10. SAFETY CULTURE PROMOTION

10.1. Introduction

Culture refers to the cumulative deposit of knowledge, experience, beliefs, values, attitudes, meanings, acquired by a group of people during generations through individual and group striving.

Safety Culture is the way safety is perceived, valued, and prioritised in an organisation. It reflects the real commitment to safety at all levels in the organisation. It is something an organisation acquires over period as a product of the combined effects of organisational culture, and professional culture.

Safety Culture's essence is in what people believe about the importance of safety, including what they think that their peers, superiors, and leaders really believe about safety as a priority.

10.2. Benefits to ANSP

Safety Culture have a direct impact on safe performance. With the safety culture, top management of ANSP show that safety is their priority, and the entire organization gives priority on safety.

An optimum Safety Culture will deliver a clearer and more comprehensive picture of operational risk, one that takes in all aspects of the activities of the organisation.

This enhancement of mutual trust with management gives a positive impact on productivity.

In an organization with a strong safety culture, individuals and groups take responsibility for safety by communicating safety concerns and striving to learn, adapt, and modify individual and organizational behaviour based on lessons learned.

10.3. Benefits to ATSEP

Safety Culture is seen as a key safety and service target so that the people at the 'sharp end' feel empowered to act in the interests of safety in the knowledge that the management will support them. This increases the mutual trust and motivation to play the safety role.

A strong safety culture helps ensure that personnel are trained and competent to perform their duties and that continual training and updates on safety progress are provided.

10.4. Actions by ANSP

Establishing better information flow and the maintenance of an effective dialogue within the organisation about safety performance as priority.

Promoting strong safety values means that all ANSP employees share lessons learned from investigations and experiences, both internally and from other organizations.

The tenets of Safety Promotion are used to foster a positive safety culture in which ANSP employees understand why safety is important and how they affect it, providing a sense of purpose to safety efforts.

Open communication is critical to a positive safety culture. ANSP communicates safety objectives to all operational personnel to improve the way safety is perceived, valued, and prioritized.

One of the initiatives that ANSP makes for maintaining positive safety culture is Voluntary Safety Reporting Programs. It is a confidential system for controllers and other employees to voluntarily identify and report safety and operational concerns.

Promoting the safety aspects of the roles played by ATSEP to the other stakeholders in ANSP so that they are not assigned with non-core activities, get the necessary information, infrastructural and other support for the operation and maintenance of CNS/ATM systems.

10.5. Actions by ATSEP

Each employee must consider the potential effect their decisions may have on safety and is responsible for understanding the significance of his or her job as it relates to safety. voluntarily identify and report safety and operational concerns.

10.6. Most Influential Countermeasure

Sensitizing all the stakeholders on the role of ATSEP in ATM service delivery and contributions to air safety.

10.7. Human Factors Issues Addressed

10.7.1. Directly addressed factors.

1	Age and condition of supporting equipment like generators, electrical installations, air conditioners etc...,
2	Diversified tasks during duty.
3	Inadequate first-hand information given by user.
4	Behind the curtain profession
5	Delayed annual and other planned preventive and corrective maintenance due to non-availability of time for maintenance actions.
6	Difference in stated corporate Mission/Vision and the ground reality.
7	Improper and unbalanced work distribution with undue over burden and undue over leniency.
8	Improper Complaint reporting mechanism by user, which do not convey the key information required for the early rectification of the equipment.
9	Innumerable, unspecified, and unpredicted works assigned to selected ATSEP preventing their attention from core maintenance tasks.
10	Insufficient logistics support and communication infrastructure to support ATSEP works, those at remote site/area.
11	Lack of effective coordination procedures for men material movements inside the operational areas of private operator owned airports.
12	Lack of mutual performance assessment as per the roles and responsibilities assigned.
13	Lack of mutual respect and common values among internal stakeholders. (ATCOs, ATSEP, Engineers)
14	Lack of planning before maintenance works. Not adhering to the schedules if planned.
15	Lack of professional communication or poor communication on technical terms to approving authority, who is mostly a non-ATSEP.
16	Lack policies and practices towards the human factors of ATSEP.
17	Multiple jobs of diversified nature in quick successions without notice or planning.

18	No say of ATSEP in HR policies being set for them.
19	Poor workload distribution makes few carries stress, pressure, fatigue, and timeline pressure throughout without any relief.
20	Timeline pressure from boss, management, ATCOs, and other stakeholders.
21	Too many unclassified additional works in smaller airports. Essential maintenance tasks skipped.
22	Where there is electronics, there shall be an ATSEP – Belief of airport in-charges.

10.8. Resilience and Cost Benefits

All ANSP have already established the SMS systems and they will have to promote safety work culture in the organization through leadership. It may add negligible additional costs but ensures ANSP to ensure safety and maintain reputation. This will also improve the commitment and productivity of internal stakeholders.

10.9. Other Countermeasures

Imparting human factors training to ATSEP and explaining the safety impacts from the perspective of human factors.

Rewarding the safety performance.

Encouraging them to voluntarily disclose the errors committed if any before major shutdown to find the root causes.

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APPENDIX 1 STRESS FACTOR MAPPING

1.1. Introduction

The excel sheet given below indicates the mapping of stress factors and countermeasures.

##	Table	Factor	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12.1	C12.2	C12.3	C12.4	C13.1	C13.2	C13.3	C13.4	C13.5	C13.6	C13.7	C13.8	C14.1	C14.2	C14.3	C14.4	C14.5	C15.1	C15.2	C15.3	C15.4	C15.5	C15.6	C15.7	C15.8	C15.9	C15.10	Top 10%	Top 20%	Top 30%	Top 40%									
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##	Table	Factor	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12.1	C12.2	C12.3	C12.4	C13.1	C13.2	C13.3	C13.4	C13.5	C13.6	C13.7	C13.8	C14.1	C14.2	C14.3	C14.4	C14.5	C15.1	C15.2	C15.3	C15.4	C15.5	C15.6	C15.7	C15.8	C15.9	C15.10	Top 10%	Top 20%	Top 30%	Top 40%					
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##	Table	Factor	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12.1	C12.2	C12.3	C12.4	C13.1	C13.2	C13.3	C13.4	C13.5	C13.6	C13.7	C13.8	C14.1	C14.2	C14.3	C14.4	C14.5	C15.1	C15.2	C15.3	C15.4	C15.5	C15.6	C15.7	C15.8	C15.9	C15.10	Top 10%	Top 20%	Top 30%	Top 40%					
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88	5	4			1																												1													0	1	1	1
89	5	5													1	1																	1												0	1	1	1	
90	5	6	1				1		1																								1												1	1	1	1	
91	5	7	1			1	1		1		1																																		1	1	1	1	
92	5	9	1																										1																1	1	1	1	
93	5	11														1		1	1	1	1												1											0	1	1	1		
94	5	12									1				1		1			1													1												0	1	1	1	
95	5	13	1				1					1																	1				1												0	1	1	1	
96	5	14					1						1													1	1							1										1	1	1	1		
97	5	15	1					1	1								1																												1	1	1	1	
98	5	16						1	1		1																							1											1	1	1	1	
99	5	17						1	1		1							1																1											1	1	1	1	
100	5	18					1	1	1	1								1																1												1	1	1	1
101	5	19			1				1																1									1				1							1	1	1	1	
102	5	20						1	1	1	1											1				1					1			1											1	1	1	1	
103	6	1									1				1																															0	1	1	1
104	6	2																																1											0	1	1	1	
105	6	3																1	1		1				1							1													0	0	1	1	
106	6	4																																											0	0	0	1	
107	6	5																																1											0	1	1	1	
108	6	6																1																1												0	1	1	1
109	6	7						1	1							1																													1	1	1	1	
110	6	8												1												1								1												1	1	1	1
111	6	9																1																1												0	1	1	1
112	6	10						1	1										1	1						1																			1	1	1	1	
113	6	11																																1											0	1	1	1	
114	6	12						1															1											1											0	1	1	1	
115	6	13									1																																		0	1	1	1	
116	6	14																	1	1	1	1											1											0	1	1	1		
117	6	15						1	1														1																						1	1	1	1	
118	6	16														1	1				1																								0	0	0	0	
119	6	17																	1	1		1				1							1												0	1	1	1	
120	6	18						1	1			1																							1	1			1	1					1	1	1	1	
121	6	19						1	1		1								1	1		1												1											1	1	1	1	
122	6	20									1																								1											0	1	1	1
123	6	21											1				1				1						1						1	1												1	1	1	1

##	Table	Factor	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12.1	C12.2	C12.3	C12.4	C13.1	C13.2	C13.3	C13.4	C13.5	C13.6	C13.7	C13.8	C14.1	C14.2	C14.3	C14.4	C14.5	C15.1	C15.2	C15.3	C15.4	C15.5	C15.6	C15.7	C15.8	C15.9	C15.10	Top 10%	Top 20%	Top 30%	Top 40%			
124	7	1		1						1	1		1			1					1					1				1											1	1	1	1			
125	7	2																											1		1											1	1	1	1		
126	7	4									1		1														1															1	1	1	1		
127	7	5		1						1	1		1														1				1											1	1	1	1		
128	7	6																													1											0	0	1	1		
129	7	7																					1				1															1	1	1	1		
130	7	9														1					1								1		1												1	1	1	1	
131	7	10																1	1		1										1											0	0	1	1		
132	7	11																									1																1	1	1	1	
133	7	12		1						1																																0	0	1	1		
134	7	13		1						1	1		1								1						1		1		1												1	1	1	1	
135	7	14														1				1								1		1		1											1	1	1	1	
136	7	15		1												1					1			1				1		1		1											1	1	1	1	
137	7	16		1									1													1																	1	1	1	1	
138	7	17																1	1						1						1											0	0	1	1		
139	7	18																														1											0	0	1	1	
140	7	19												1															1		1	1												1	1	1	1
141	7	20												1															1		1		1											1	1	1	1
142	7	21									1																		1		1		1											1	1	1	1
143	7	22												1										1							1												0	0	1	1	
144	7	23		1						1	1		1	1												1					1												1	1	1	1	
145	8	1																											1															1	1	1	1
146	8	2																											1															1	1	1	1
147	8	3	1		1				1																				1														1	1	1	1	
148	8	4																											1															1	1	1	1
149	8	5																											1															1	1	1	1
150	8	6	1						1																				1														1	1	1	1	
151	8	7	1		1																								1														1	1	1	1	
152	8	8	1																										1															1	1	1	1
153	8	9	1														1												1					1									1	1	1	1	
154	8	10																											1															1	1	1	1
155	8	11	1		1																								1														1	1	1	1	
156	8	12	1														1												1														1	1	1	1	
157	B7	1	1																										1														1	1	1	1	
158	B7	2	1																										1														1	1	1	1	
159	B7	3																											1															1	1	1	1
160	B7	4																											1															1	1	1	1
161	B8	1		1							1			1							1		1																				0	1	1	1	
162	B8	2																1	1		1		1						1														1	1	1	1	
163	B8	3								1	1		1														1						1										1	1	1	1	
164	B8	4																											1															1	1	1	1
165	B9	1					1	1	1													1																					1	1	1	1	
166	B9	2	1						1					1	1																												1	1	1	1	

##	Table	Factor	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12.1	C12.2	C12.3	C12.4	C13.1	C13.2	C13.3	C13.4	C13.5	C13.6	C13.7	C13.8	C14.1	C14.2	C14.3	C14.4	C14.5	C15.1	C15.2	C15.3	C15.4	C15.5	C15.6	C15.7	C15.8	C15.9	C15.10	Top 10%	Top 20%	Top 30%	Top 40%	
167	B9	3	1																										1											1	1	1	1		
168	B9	4						1	1													1				1			1											1	1	1	1		
169	B10	1	1				1																				1						1	1						0	1	1	1		
170	B10	2																										1				1								1	1	1	1		
171	B10	3				1		1	1													1							1				1	1						1	1	1	1		
172	B10	4						1	1													1											1	1	1				1	1	1	1			
173	B11	1		1						1	1		1														1													1	1	1	1		
174	B11	2		1			1	1	1	1			1									1					1	1		1										1	1	1	1		
175	B11	3		1						1	1		1														1														1	1	1	1	
176	B11	4		1						1																	1			1												1	1	1	1
			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12.1	C12.2	C12.3	C12.4	C13.1	C13.2	C13.3	C13.4	C13.5	C13.6	C13.7	C13.8	C14.1	C14.2	C14.3	C14.4	C14.5	C15.1	C15.2	C15.3	C15.4	C15.5	C15.6	C15.7	C15.8	C15.9	C15.10	125	161	172	175	
			38	25	12	16	24	43	45	23	33	12	47	22	10	16	13	12	12	14	10	21	5	10	6	51	15	58	28	32	36	26	19	13	7	18	10	11	2	6					
Top 10%			38	25	12	16	24	43	45	23	33	12	47	22	10	16	13	12	12	14	10	21	5	10	6	51	15	58	28	32	36	26	19	13	7	18	10	11	2	6	71%				
Top 20%			38	25	12	16	24	43	45	23	33	12	47	22	10	16	13	12	12	14	10	21	5	10	6	51	15	58	28	32	36	26	19	13	7	18	10	11	2	6		91%			
Top 30%			38	25	12	16	24	43	45	23	33	12	47	22	10	16	13	12	12	14	10	21	5	10	6	51	15	58	28	32	36	26	19	13	7	18	10	11	2	6			98%		
Top 40%			38	25	12	16	24	43	45	23	33	12	47	22	10	16	13	12	12	14	10	21	5	10	6	51	15	58	28	32	36	26	19	13	7	18	10	11	2	6				99%	

1.2. Description

All the green cells with “1” indicates the mapping of factor with the countermeasure. Coloured cells in Top 10%, 20%, 30%, and 40% rows indicate the most influential countermeasures.

Cell value “1” in Top 10%, 20% 30%, and 40% columns indicates that the factor is addressed either directly or indirectly by the most influential countermeasures in respective %age.

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APPENDIX 2 STRESS FACTORS

2.1. Introduction

2.1.1. Table 1 – Lack of Knowledge, Skills, and Competency.

Table 1: Factors that affect the job performance due to the lack of KSA, Competency in coping with the successive induction of modern technologies	
1	Preparing technical specification for a new system without knowing the local government guidelines and latest technology available.
2	No clear job description, roles and responsibilities are varying after each movement, deployed at non-core areas.
3	Lack of opportunity for developing and or retaining core competencies due to deployment in non-core areas for a prolonged period before and after equipment training.
4	Lack of equipment training even after years of deployment in the unit.
5	Lack of KSA and Competency to manage complex modern equipment.
6	No clear demarcation of technical and managerial responsibilities among the junior ATSEP and senior ATSEP.
7	Improper training (Training, assessing and evaluation) for the required competencies. There is a gap in the training provided and the practical work environment.
8	Lack of skills and competencies in managing the CNS/ATM automation systems (Configuration, adaptation, replacement and upgrading the network devices, operating systems, shared storage devices, firewalls, and device drivers etc..,) due to lack of OEM documentations.
9	Forced to do tasks even without qualification (attending power lines of UPS and working at heights etc..)
10	Compromising qualities, essential OEM documentations, training and after acquisition supports on new systems against the cost (L1).
11	Procedural delays and extended file works on spare procurements.
12	Deployment of competent persons in right place after equipment training.
13	Lack of job rotation and equal opportunities.
14	Lack of knowledge in handling emergencies and disastrous situations.
15	Requirement of diversified expertise (Cyber security, Information technology, interface devices, data convertors, communication lines and links) other than core equipment for maintaining the service level.
16	Lack of project management skills and competencies at the same time, simultaneous operation and projects tasks given with unrealistic timelines.
17	Unable to resolve external interference problems and other typical problems not covered in the training.
18	Managerial or higher responsibilities without proper training.
19	Lack of knowledge in managing the available scarce human resources for maximum performance due to lack of soft skills.
20	Lack of operational training to develop competency on the old generation equipment even after service life expansion program in place.

21	Lack of opportunity to develop expertise on networking, operating systems, cyber security, project management etc. due to lack of in-house expertise instructors and training infrastructure.
22	Lack of external training, workshops, and seminars to keeping up-to-date knowledge on modern technology and systems well before the systems getting inducted.
23	Lack of involvements of frontline experts in policies designed for improving the performance of frontline experts.
24	ATSEP desire for recognition on all the facilities (CNS/ATM Automation) and on different makes and models.

2.1.2. Table 2 – Lack of proper workload distribution.

Table 2: Factors that affect the job performance due to improper workload management within the available scarce competent human resources.	
1	Less human resources for core jobs but deployment in non-core areas like terminal management, security systems, airport systems, administration works, commercial, and general stores.
2	Too many additional facilities added into ANSP like RADARS, CNS/ATM automation facilities, Nav-Aids at new airports and new RWYs in the last decade, without augmenting the human and other resources.
3	No alternate/standby operational team to share the workload even at emergency.
4	Single man shift.
5	Simultaneous project supervision and maintenance activities without additional manpower.
6	Manhours spent in Cargo, Customs clearance, without proper expertise or supporting staff instead of spending time on critical maintenance works and project works.
7	Innumerable, unspecified, and unpredicted works assigned to selected ATSEP preventing their attention from core maintenance tasks.
8	Permanent combined duties due to shortage of manpower increases workload and reduces the attention in all the combined units.
9	Too many unclassified additional works in smaller airports. Essential maintenance tasks skipped.
10	Where there is electronics, there shall be an ATSEP – Belief of airport in-charges.
11	Improper and unbalanced work distribution with undue over burden and undue over leniency.
12	Additional tasks assigned by regional and or corporate head quarter in addition to local airport works. (QR preparation, tender evaluation, course development, etc.,)
13	Acceptance of inefficient manpower by management without any mitigation.
14	Lack of OEM documentation increases the workload in preparing the maintenance procedures in-house.
15	Non-utilization of technologies and machines for the installation and maintenance works and planning.
16	Managing the procurement tasks and maintenance tasks of multiple airports in addition to the local.
17	Multiple jobs of diversified nature in quick successions without notice or planning.
18	No clear demarcation of competencies so spending more time on KSC update on all areas without even having the access to the equipment and facilities. (Too many make and models)

19	Frequent failures and outages of out-lived equipment and facilities.
20	Sudden failures of the systems due to natural calamities and power supply issues.
21	Lack of training and documentation increases workload and time.
22	Approval of projects without looking into the resource's requirements like human, vehicles, and other support. Workload increases on coordinating for essential supporting resources and prevents the concentration on core project activities as well as to skip the maintenance activities of ongoing operational facilities.

2.1.3. Table 3 – Lack of proper procedures, information, tools, and practices.

Table 3: Factors that affect the job performance due to improper procedures, information, tools, and practices.	
1	Poor OEM documentation on system, diagnostic procedures, site adaptable parameters and on HMI.
2	Lack of readily available spare parts and poor supply chain management makes the recovery delays after emergencies and disasters.
3	Lack of planning before maintenance works. Not adhering to the schedules if planned.
4	Too much of file works for a low-cost but immediate and essential spare procurement.
5	Insufficient logistics support and communication infrastructure to support ATSEP works, those at remote site/area.
6	Inaccurate procedures, lack of tested and validated SOPs leads to corrective maintenance delays.
7	Lack of document control and missing acknowledgement on new update on regulations and operational procedures.
8	Age and condition of supporting equipment like generators, electrical installations, air conditioners etc...,
9	Delayed flight calibration due to poor preparation and planning.
10	Delayed annual and other planned preventive and corrective maintenance due to non-availability of time for maintenance actions.
11	Non availability of calibrated working test equipment as required for the preventive as well as for the corrective maintenance.
12	Continuous changes in the scope and requirements on complex projects from the user point of view, without proper consideration from the maintenance point of view.
13	In compatible interfaces and data formats among different makes and models for integration and extending the data and voice to other ACC or APP airports.
14	Little or no-hands on training
15	Faulty equipment design and or faulty alert mechanism. Mis-leading front panel indications and irrelevant documentations. Unknown bug and or hidden deficiencies cropping up after the warranty and service agreement.
16	Frequent failures of OFC and leased lines connectivity. Non availability of near perfect cable or line diagrams for OFCs and power lines in the operational area.
17	Improper Complaint reporting mechanism by user, which do not convey the key information required for the early rectification of the equipment.
18	Annual plan for ATSEP training and development in line with the operational and competency requirements.
19	Lack of effective coordination procedures for men material movements inside the operational areas of private operator owned airports.

20	Lack of effective annual spare and capital procurement plan and related budget provisions.
21	Lack of update in the maintenance procedures, operating procedures, and maintenance philosophies in line with the technologies.
22	User requirements defined not met with the supplied system.
23	Mismatching in course development that does not make the ATSEP competent enough to address the practical field issues.

2.1.4. Table 4 – Duty duration, cycles of shifts and extended work hours.

Table 4: Factors that affect the job performance due to duty duration, cycles of shifts, late night calls and other late hour maintenance works without breaks and rests.	
1	No standardized duty pattern, duration, breaks and rest periods
2	Extra shift duties are forced due to shortage of manpower
3	Sleep loss due to irregular shift pattern or fast rotating shift pattern
4	Lack of time to family
5	Late hour calls and frequent calls after duty hours even during weekly OFFs
6	Irregular duty calls without any pattern due to shortage of manpower
7	Must report again by 0930AM even after late night breakdown calls and late-night project works.
8	No clear OFFs before shift pattern changes
9	Leave requests not approved
10	Forced to carryout major maintenance works only during late night and need to return to duty next day by 0930AM.
11	No refreshment breaks
12	Lack of attractive compensation for extra shift works performed
13	Odd hours and on field shift duties for women ATSEP without basic rest room facilities in the operational sites.
14	Stressful 12 hours night shift without breaks and rests
15	Continuous works including weekends during the demanding situations for meeting the special maintenance and project works along with routine operational works.

2.1.5. Table 5 – Continued stress, fatigue, and pressure.

Table 5: Factors that affect the job performance due to continued stress, fatigue, pressure, time pressure and deadlines on multiple tasks.	
1	24H operations with stringent regulatory compliance.
2	Mostly corrective maintenance work conducted at night.
3	Repairing critical modules of the facilities that are under NOTAM
4	Safety consciousness in keeping the facilities available all the time.
5	Timeline pressure from boss, management, ATCOs, and other stakeholders.
6	Sense of expectation on out-lived equipment failures even while conducting preventive maintenance.
7	Extraordinary file work delays in getting approvals for proceeding to next stages.
8	Frequent movement to and from in between ATC complex and different operational sites especially in case of A-SMGCS, ILS sites and multiple RADAR sites for daily checks and maintenance work.
9	Peer pressure due to evaluation and comments from colleagues who are not accountable
10	Poor workload distribution makes few carries stress, pressure, fatigue, and timeline pressure throughout without any relief.
11	Being helpless in rectifying the unit after knowing inherent flaws in the design of the equipment and its unreliability
12	Often project deadlines are set without freezing the scopes and augmenting with necessary resources.
13	Trouble shooting in busy working environment on live interconnected systems.
14	Always under pressure to give back the facilities within the EST of NOTAM
15	Expectations on making quick decision, in less reactive time with zero error tolerance and on fixing the system immediately.
16	Constant mind switchover between old and modern technologies, procedures, tools etc., within the same service facilities. Different aged, make and model of equipment within a single service facility like VHF, Nav-Aids, and surveillance.
17	Unrealistic timelines due to poor planning and coordination with ATCOs before making maintenance activities.
18	Lack of knowledge and expert support while trying to fix an unfamiliar technical glitch.

2.1.6. Table 6 – Lack of knowledge sharing, leadership, and teamwork.

Table 6: Factors that affect the job performance due to poor leadership, lack of knowledge sharing, lack of communication, and lack of teamwork.	
1	Lack of mutual performance assessment as per the roles and responsibilities assigned.
2	Lack of leadership in building relationships and establishing communication or coordination frameworks with internal as well as external stakeholders.
3	Frontline ATSEP views ignored, and not recognized as experts.
4	Lack of professional communication or poor communication on technical terms to approving authority, who is mostly a non-ATSEP.
5	Lack of mutual respect and common values among internal stakeholders. (ATCOs, ATSEP, Engineers)
6	Lack of leadership in ensuring the safety conscious among sub-ordinate, instead of being reactive and blaming.
7	Impact of changes not communicated, and individuals are reluctant to adopt.
8	Frequent changes in the team members or team lead prevents better teamwork and communications.
9	Lack of leadership in managing conflicts and ensuring team goals and safety objectives over individuals interests and goals.
10	Lack of brainstorming on handling unfamiliar situation and regular interactions for knowledge sharing.
11	Lack of leadership in handling professional disagreement with internal and external stakeholders and pass it to frontline ATSEP.
12	Lack of knowledge sharing on latest developments in local airport level and in ANSP level to frontline ATSEP.
13	Lack of delegation or poor overlapping delegation and preferences towards frontline tasks not on managerial or leadership tasks.
14	Lack of mutual respect and mentorship for knowledge and experience sharing among the generations.
15	Lack of self-learning tools
16	Lack of corrective measure in addressing the commitment levels and contributions of ATSEP.
17	Lack of guidance, information exchange, and non-participation in the discussion make the freshers isolated.
18	Lack of knowledge on critical maintenance aspects of the equipment outsourced.
19	Lack of teamwork, more dependency on individuals and collective inputs not taken by team lead for decision.
20	Lack of leadership in communicating the priorities to sub-ordinates.
21	Inhibition of valuable suggestions and ideas due to the overload of works.

2.1.7. Table 7 – Human Resource Management policies.

Table 7: Factors that affect the job performance due to poor selection, human resource management policies and other organizational policies affect the motivation levels.	
1	Lack of support on career development and career plan.
2	Payment delays.
3	Lack of fresh recruitments, but more retirements and induction of new equipment.
4	Uncertainty on future roles and responsibilities.
5	Sense of being unheard by management
6	Lack of competitive colleagues. People with substandard knowledge and skills are getting selected.
7	Lack of motivating compensations for extra manhours spent in general maintenance, VVIP movements, project works, additional works, and additional shifts.
8	Lack of opportunity and fund provisions for innovation and carry station level smaller projects.
9	Selection criteria for inducting various levels of ATSEP for ensuring more competent people recruited in the higher levels.
10	Lack of regulatory requirements for complying standardized trainings and licencing to ATSEP
11	Lack of pride as not recognized as expert in particular field and transferred anywhere without considering the competencies acquired.
12	Salary and allowances not at par with the industry standards for the level of stress and workload.
13	Lack of scientific annual performance assessment and rewarding scheme considering the unique working environment and expected level of performance of ATSEP.
14	Lack of job rotation.
15	Lack of involvements in the discussion sessions and feedback sessions on major policy decisions.
16	Mandatory transfers
17	Lack policies and practices towards the human factors of ATSEP.
18	Behind the curtain profession
19	Gender bias and equal field works not assigned to women ATSEP.
20	No say of ATSEP in HR policies being set for them.
21	Difference in stated corporate Mission/Vision and the ground reality.

2.1.8. Table 8 – Lack of workplace facilities and environment.

Table 8: Factors that affect the job performance due to lack of workplace facilities and environment.	
1	Lack of basic workplace facilities like parking, canteen, fixtures, rest rooms, vending machines, common transport for pickup and drop from employee quarters to workplace, etc.,
2	Lack of specific workplace facilities for women like identified rest rooms in the operational areas, Creche, childcare leave, etc...,
3	Lack of protection and guidelines while attending equipment during heavy lightning and abnormal weather conditions.
4	Below par and uncomfortable residential facilities at faraway places instead of provisions of comfortable nearby quarters with reasonable rent.
5	Travelling long distance from home to workplace as green field airports are situated at outer part of the cities and no provision of common transportation facility.
6	Lack of guidelines and provisions of PPE to ATSEP for protecting them while working at highly polluted with noise and dust, heights, closer to high power radiating radars, X-rays, etc.,
7	There is a long wait and no provision of comfortable and appropriate mode of commute to approach remote sites even though during scorching summer days.
8	Frequent exposure of high outside remote site temperature and less inside equipment room temperature in a shift.
9	Narrow space around equipment racks filled with too many wires and connections, making difficulties in accessing and replacing the modules.
10	Congested or no desk / table. Too many items placed in the control and monitoring room. No space for keeping important manuals, procedures, SOPs in most visible and accessible manner.
11	Installations at very remote places, and high mountains preventing regular visits due to resources.
12	Difficulties in trouble shooting behind the ATC consoles in general and at late night hours due to poor lighting at the behind the console.

2.1.9. Most Significant Factors as per ATSEP

Factors that affect the health
B.7.1. Frequent (change of) exposure to too low temperature in the server or equipment room and too high outside temperature.
B.7.2. No access of fresh air and sunlight for long duration.
B.7.3. Working under severe dust pollution during the project work.
B.7.4. Working under noise pollution in the airfield.
Factors that affect the attention
B.8.1. Diversified tasks during duty.
B.8.2. Monotonous monitoring for a long time.
B.8.3. Combined project and operational tasks.
B.8.4. Working in lower temperature in equipment room.
Factors that affect the response time
B.9.1. Fear on consequences of failure while trouble shooting in live system.
B.9.2. Inadequate first-hand information given by user.
B.9.3. Non availability of vehicle to reach the remote site.
B.9.4. Short of ideas; being alone.
The training that are most preferred by manager level ATSEP
B.10.1. Planning (for replacement of obsolete system) and procurement.
B.10.2. Stress and fatigue management.
B.10.3. Project management.
B.10.4. Contract management.
Most significant roadblock that prevents ATSEP in developing their competencies and expertise
B.11.1. Expected competencies in all domains of CNS/ATM systems.
B.11.2. Different make and model for each facility / system.
B.11.3. Deployment in non-core activities for longer duration.
B.11.4. Compulsory movements within the nation during service life

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APPENDIX 3 COUNTERMEASURES

3.1. Introduction

C.1. Reviewing maintenance philosophies, utilizing technologies, and bringing innovation to supervise CNS/ATM systems for reducing paper works, physical visits and saving manhours.
C.2. Improving the safety job performance of ATSEP by restricting their deployment within the scope defined in DOC 10057
C.3. Pre-planning the pre-monsoon, annual and other major preventive maintenance tasks well in advance and carrying out the tasks as planned. So that sudden or total failures and long corrective maintenance works prevented
C.4. Roadblocks on procurement process can be reduced by training selected ATSEP on government compliance requirements by experts having background on the financial regulation. ATSEP those who participate in the major or repeated procurement process can be permitted to have consultants on these areas
C.5. Pro-active procurement and replacement policies in managing the out-lived equipment will reduce the stress among the key stake holders of ANSP due to their safety commitment
C.6. ANSP level scientific knowledge management on operations, maintenance, projects, and emergencies will reduce the stress significantly as ATSEP are continuously learning the latest problems and solutions and be ready with the proven techniques
C.7. By providing only optimum number of verified and validated SOPs without redundancy, the stress of restoring facilities in brief time, will reduce significantly
C.8. By limiting their stream of competency among CNS/ATM facilities, higher levels of expertise and competencies can be developed and retained.
C.9. By defining the roles and responsibilities clearly along with accountabilities, individual job performance of ATSEP will increase and in-turn over all safety performance of ANSP will also increase.
C.10. By ensuring necessary OEM documentation and support on spare that suits the maintenance philosophies of the ANSP, overall effectiveness of corrective maintenance will improve.
C.11. With regular optimum augmentation of human resource based on the existing tasks, expected retirements, and expected additional facilities, the stress and fatigue levels of ATSEP can be brought to a minimum and safety goals can be assured.
C.12. To ensure the fullest commitment of all the ATSEP on safety tasks, ANSPs must encourage the safety work culture in the working environment of ATSEP to make sure that no ATSEP is left out. ANSPs can improve safety work culture by taking the following measures:
C.12.1. Sensitizing all the stakeholders on the role of ATSEP in ATM service delivery and contributions to air safety
C.12.2. Imparting human factors training to ATSEP and explaining the safety impacts from the perspective of human factors
C.12.3. Rewarding the safety performance
C.12.4. Encouraging them to voluntarily disclose the errors committed before major shutdown to find the root causes.
C.13. To prevent the ATSEP to be complacent and getting bored on repeated tasks, ANSPs must try to engage them during shift duties constructively so that they remain engaged and remain alert to handle the unexpected. ANSPs can improve the engagement of duty ATSEP by taking the following measures.

C.13.1. Encourage innovation on routine tasks.
C.13.2. Promote research groups within the ANSP
C.13.3. Rewards and promotion based on contribution and effort
C.13.4. Assign dedicated small assignments based on the specific talents and skills.
C.13.5. Provisioning online based self-learning tools
C 13.6. Random Fault Simulation (Mock drills) and performance assessment of ATSEP based on this exercise.
C 13.7. Innovative ideas should be welcomed through brainstorming sessions with the frontline experts before making major policies and procurements of new systems.
C 13.8. By limiting their stream of competency and developing higher level expertise and competencies, national level backup team can be formed for emergency, disaster, and pandemic situation.
C.14. To keep the motivation level of ATSEP to progress continuously upward, ANSPs need to adopt the best practices in their work environment. It is a human nature to benchmark their organization and work environment with that of others. So, ANSPs need to keep adopting the best practices into the working environment. Some of the best practices that can be adopted are
C.14.1. Assessing optimum manpower requirement, recruit competent people, train, deploy and promote accordingly.
C.14.2. Following procurement policies that facilitates buying quality systems.
C.14.3. Providing working environment, with consideration to human factor issues of ATSEP
C.14.4. Conducting seminar on best practices adopted at different airports within ANSP.
C.14.5. Following HR policies that encourages recognition, appreciation, and suitable compensations.
C.15. Knowledge, skills, attitude, and competencies of ATSEP are very essential for their safety job performance. ATSEP job performance is essential for meeting the safety goals of any ANSPs. The following are among the essential competency developments on which ANSPs can focus in developing on their ATSEP.
C.15.1. Train ATSEP in human factors as per DOC 10057 in various levels that suits their technical and managerial accountabilities
C.15.2. Train ATSEP on Engineering module as per DOC 10057 that suits the ANSP roles on projects and procurements
C.15.3. Developing competency for preparing upcoming complex CNS/ATM systems' specifications.
C.15.4. Developing Communication skills for effective communications with internal and external stakeholders.
C.15.5. Developing skills for preparing detailed project reports and technical reports
C.15.6. Developing skills for analysing the external interference, external interfaces, data formats, communication protocol and communication links associated with CNS/ATM facilities.
C.15.7. Training on infrastructure as per DOC 10057.
C.15.8. Training on factory and site acceptance tests of major systems for verifying the performance of the system compliance of user requirement and tender terms and conditions.
C.15.9. Training on handling emergency and disaster situations.
C 15.10 Soft skill development to increase the productivity – project management, contract management, Teambuilding, and other relevant skills.

APPENDIX 4 ATSEP DUTY TIME LIMITATION

4.1. Introduction

As humans, we each have a unique living, breathing set of capabilities. We also have an innate set of fears: at the workplace, this can translate to fear of criticism, fear of uncertainty, and fear of harming one's career. Organizations that prioritize and strengthen employee development not only enable their workers to realize their full career potential but also foster an organizational culture of innovation.

It is no longer a surprise that people seek more from their employers than just a paycheck and a safe place to work. A preponderance of evidence suggests that “good work” also means satisfying employees' psychological needs. (Meet the psychological needs of your people--all your people | McKinsey).

“Duty working hours” means the period during which an employee is available for employment. “Duty working Hour” is an integral part of the workspace environment and a crucial factor in determining the psychological needs of an ATSEP.

There have been incidents of traffic diversions, partial or full closure of airport operations due to non-availability of safety critical Air Navigation Facilities. Accidents cannot be ruled out if the stress and fatigue issues of ATSEP are not addressed. Better workspace environments are key factors in reducing their stress and fatigue.

4.2. Definitions

- Period of Duty - The period during which the ATSEP is required to carry out any task associated with the CNS/ATM service provider, includes breaks and any extension of duty.
- Operational duty - the period that an ATSEP is really using their knowledge of equipment for providing CNS/ATM service to end users.
- Night duty - A period of duty of not less than four hours between 2200 hours and 0700 hours next following in local time.

4.3. Background

Throughout the operation and maintenance work profile, an ATSEP must be vigilant and effective, prepared to handle any unanticipated circumstances that may arise, such as the effects of degradation of equipment, equipment failure due severe weather or visit to a remote place without any support. Ergo, Extreme anxiety and stress arise.

A Survey was conducted across various ANSP to analyse prevailing working hours and shift pattern which may assist us in defining the best policies and practices around the globe to make ATSEP work environment better and efficient.

From the following three graphs, ATSEP worldwide work under difficult working environments due to a lack of duty time guidelines, which results in poor job performance due to duty duration, shift cycles, late-night calls, and other late-hour maintenance work without breaks and rests.

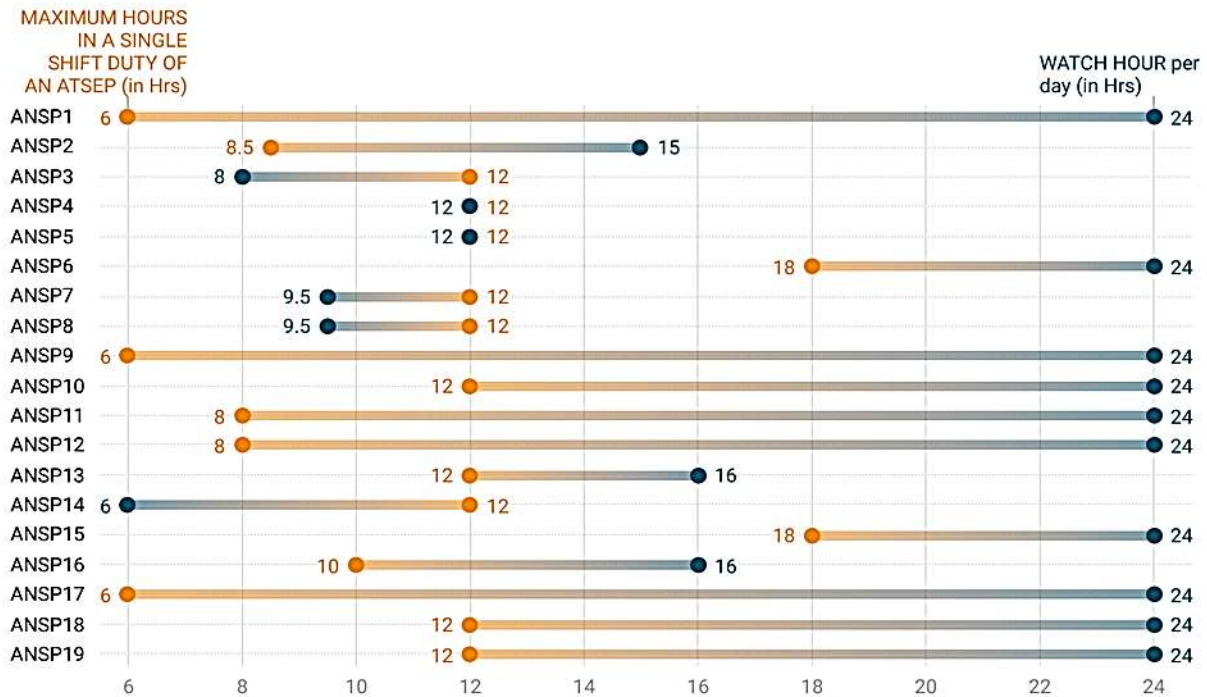


Figure 5: ATSEP Duty Time Analysis - 1

Plot Between “Watch Hour per Day (In Hrs)” vs “Maximum Hour in a Single Shift”

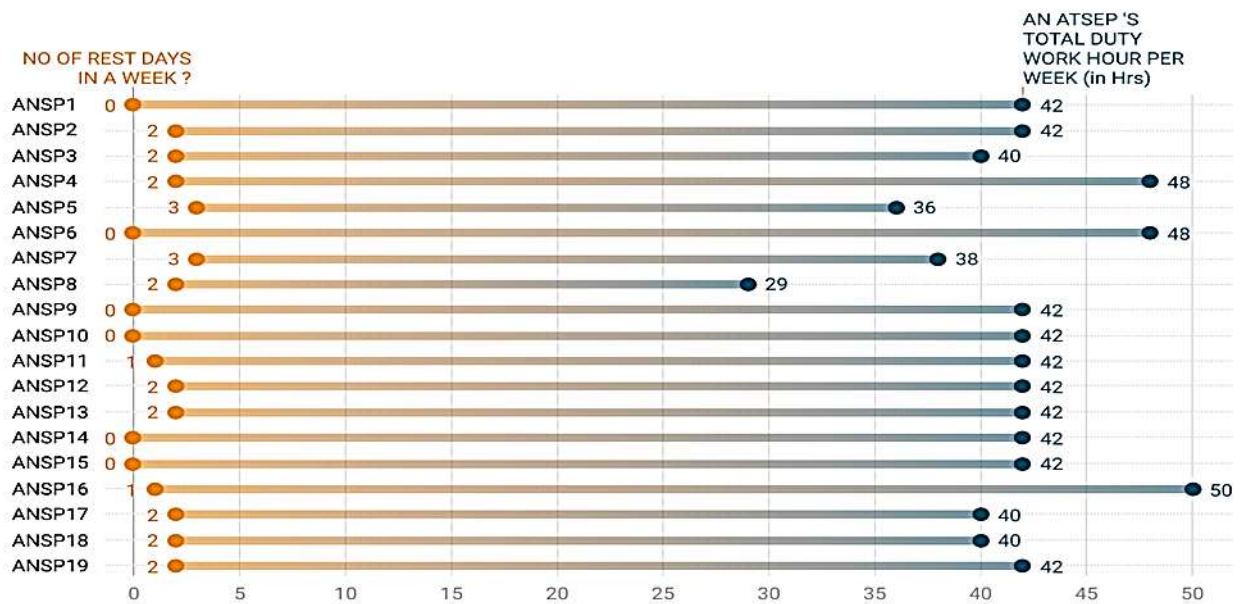


Figure 6: ATSEP Duty Time Analysis - 2

Plot Between “Total Duty Hours per week” vs “Number of Rest Days in week”

Plot Between “Any Break During the break (in Hrs)” vs “Maximum Hour in a Single Shift (In Hrs)”

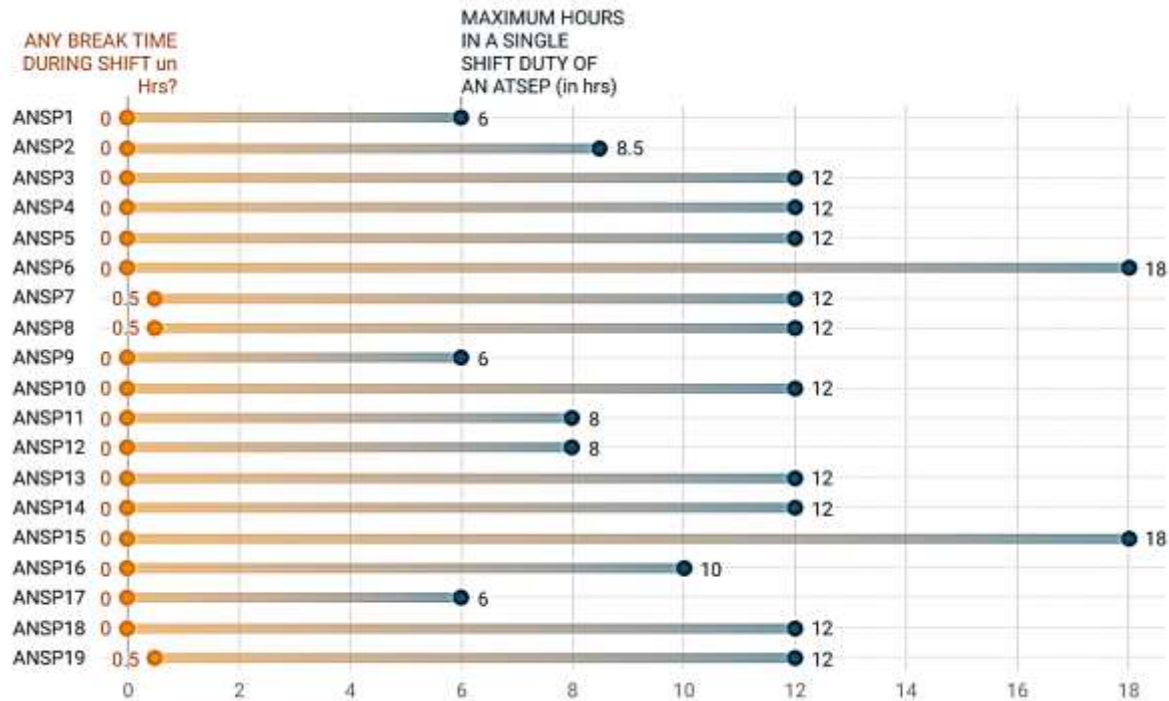


Figure 7: ATSEP Duty Time Analysis - 3

4.4. Best Shift duty pattern

Circadian systems need to be considered in relation to three differing levels of organization of information and operation. First is the way in which the physical environment communicates (or 'Inputs') key information, particularly related to differentiation of night from day to the internal 'master' clock (located in the brain's suprachiasmatic nucleus (SCN)). Second are the 'Intrinsic' brain factors, consisting of the master clock and its linked regulatory systems (notably secretion of melatonin from the pineal gland). These contribute to sleep onset, sleep architecture, sleep-wake cycles, and other central nervous system (CNS)-dependent behavioural changes. Third is the way in which the circadian system coordinates all other hormonal, metabolic, immune, thermoregulatory, autonomic nervous and other physiological processes to optimize the relationships between behaviour and body functions (that is, the 'Outputs') (reference: Manipulating the sleep-wake cycle and circadian rhythms to improve clinical management of major depression).

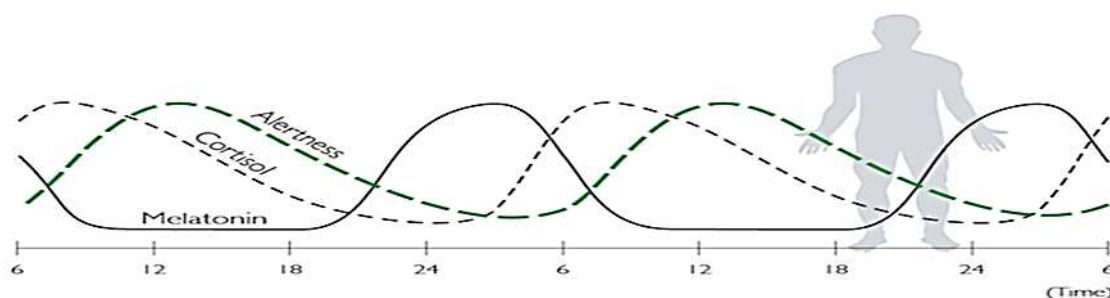


Figure 8: Sleep / Wake Cycle

The human organs are orchestrated to work in harmony with each other, generating a body rhythm that is set everyday by daylight. This rhythm is called the circadian rhythm and includes production and secretion of hormones to regulate functions such as body temperature, awareness, and immune system activity.

Because of the reduced traffic volume or no traffic, maintenance of CNS facilities is frequently performed at night. We are aware of this reality, but we also need to consider factors like human factor, safety concerns.

The most common maintenance systems/practices in use are planned, predictive, scheduled, corrective and emergency.

- **Planned maintenance** - Planned maintenance refers to any strategy where you plan and perform maintenance tasks before a fault occurs. Preventive maintenance is more specific.
- **Predictive maintenance** - Predictive maintenance is a strategy that tracks equipment's performance while it is in use using condition-monitoring technologies and methods.
- **Corrective maintenance** - Corrective maintenance (CM) involves the replacement or repair of equipment after it fails.
- **Emergency maintenance** - Emergency maintenance, also known as breakdown maintenance, is maintenance required when an asset or piece of equipment suffers an unexpected breakdown.



Figure 9: Shift Duties Effect on Health

4.4.1. Shift work with ATSEP performance and Aviation safety

Number of successive night shifts

- The chance of errors and accidents rises with the number of subsequent night shifts; the risk is 13% greater on the second night, 25% higher on the third, and 45% higher on the fourth.

- Up to a shift cycle of seven consecutive shifts, the risk for each shift block increases with the length of the blocks and is dependent on the number of consecutive nights.
- The results agree with findings about performance reduction due to fatigue.

Shift length

- Vernon (1921, 1940) was the first to note that working twelve instead of eight hours raised the chance of an accident by a factor of 1.5 to 2
- Studies have shown that in extended shifts:
 - 1) Fatigue and the risk of incidents is increased
 - 2) Productivity is decreased
 - 3) Employees are longer exposed to higher stress levels
- However, Twelve-hour shifts are highly preferred by employees since they allow them more spare time by reducing the number of trips to the workplace.

Night shift

- The ability of employees to work at night is fundamentally constrained by their biological clocks and levels of activation during the day, respectively.
- Significantly decreased productivity and performance from 7 p.m. to 7 a.m.
- Human Performance found to be lower, especially between midnight and six in the morning. (2003's Folkard and Tucker).
- However, alternative, and occasionally less dangerous duties are regularly carried out at night.

Shift work and productivity

- Productivity in the field of economics is defined as the ratio of the quantity and quality of units produced to the labour per unit of time
- In CNS/ATM, productivity is usually seen in safety, low amount of delays due a smaller number of missed approaches, communication failure, equipment failure.
- Productivity is not only dependent on the right amount of arousal, but also on the number of hours worked, night work, allocation of breaks and type of roster.

Shift work and efficiency

- The term efficiency means an ability to perform well or achieve a result without wasted energy, resources, effort, time, or money.
- The following are the main shift work impacts on efficiency:

- a. Shift length-varied, contained, or extended,
- b. Shift starting time-staggered or rigid, matched, or circadian rhythm or not,
- c. Overlapping shifts-single shifts overlap each other
- d. Break times-fixed or varied according to traffic demand,
- e. Break facilities-exercise, relaxation, meals,
- f. Roster cycle-short or long,
- g. Roster organization-individual or team,
- h. Advance notice of duty-short or long,
- i. Management of time leakage
- j. Management of overtime

4.4.2. Shift work design

1. Shift system design calls for an elevated level of expertise, knowledge, and experience on the part of the designer.
2. The design of shift systems aims to create a working-time organization that considers the company's interests (safety, productivity, and efficiency), health-affecting factors, social impairments, as well as individual preferences.
3. The specific circumstances of the work situation, the workload, its spatial and temporal distribution, the individual conditions, such as age, attitude, and social support, as well as the organizational frame, play a crucial role in the design of shift systems.

4.5. Guidelines for best shift duty pattern

4.5.1. Guideline 1 - Successive night shifts

The number of successive night shifts should be as low as possible; it should not exceed three-night shifts in a row.

Explanation

- 1) Many shift workers having a schedule of five or more successive night shifts feel that their body has adapted, there is genuine adaptation of the body functions to working at night.
- 2) Working successive night shifts causes an accumulation of sleep deficiency with reduced sleep quality. To health damages the risk of accidents is increased due to the increasing fatigue.
- 3) The number of night shifts does not only affect health, but also social relations.
- 4) Working at night means working against the body clock. Therefore, the night shift period should be as short as possible.

- 5) The number of the successive night shifts should be as low as possible to avoid an accumulation of sleep deficiency and negative social consequences, respectively.

4.5.2. Guideline 2 - Rest period between night shifts

After a night shift, the rest period should be if possible. The resting time should not be less than 24 hours.

Explanation

- 1) Scientific research has shown that working night shifts carries an additional risk on top of the tasks involved in the profession. Considering this, workers ought to be given additional downtime following their night shift.
- 2) The ideal recovery period is 48 hours. Unfortunately, it is difficult to always keep this advice in mind when putting it into reality.
- 3) Night shift work is regarded as an added risk. As a result, the time spent relaxing following a night shift needs to be increased. It is important to consider the features of cohesive leisure time.

4.5.3. Guideline 3 - Coherent blocked free time at the weekends

Coherent, 'blocked' free time at the weekend is to be preferred to single days off during the weekend),

Explanation

- 1) Even though the structure of the workweek is diversifying, the weekend still occupies a prominent position.
- 2) Most workers place a much higher value on free time on the weekends than they do during the workweek.
- 3) Coherent weekend free time is defined as two consecutive weekends with at least one Saturday and one Sunday being completely free. For instance, Friday and Saturday, Saturday and Sunday, or Sunday and Monday are all combinations.

4.5.4. Guideline 4 - Number of free days

Shift workers should have more free days per year than employees on day duty.

Explanation

- 1) Working on the weekends and on holidays should be compensated with leisure time even with a continuous production method.
- 2) Additionally, compensating for the added stress brought on by working night shifts.
- 3) The payment should be made in the form of free time. Additional free days are to be offered based on the number of night shifts.

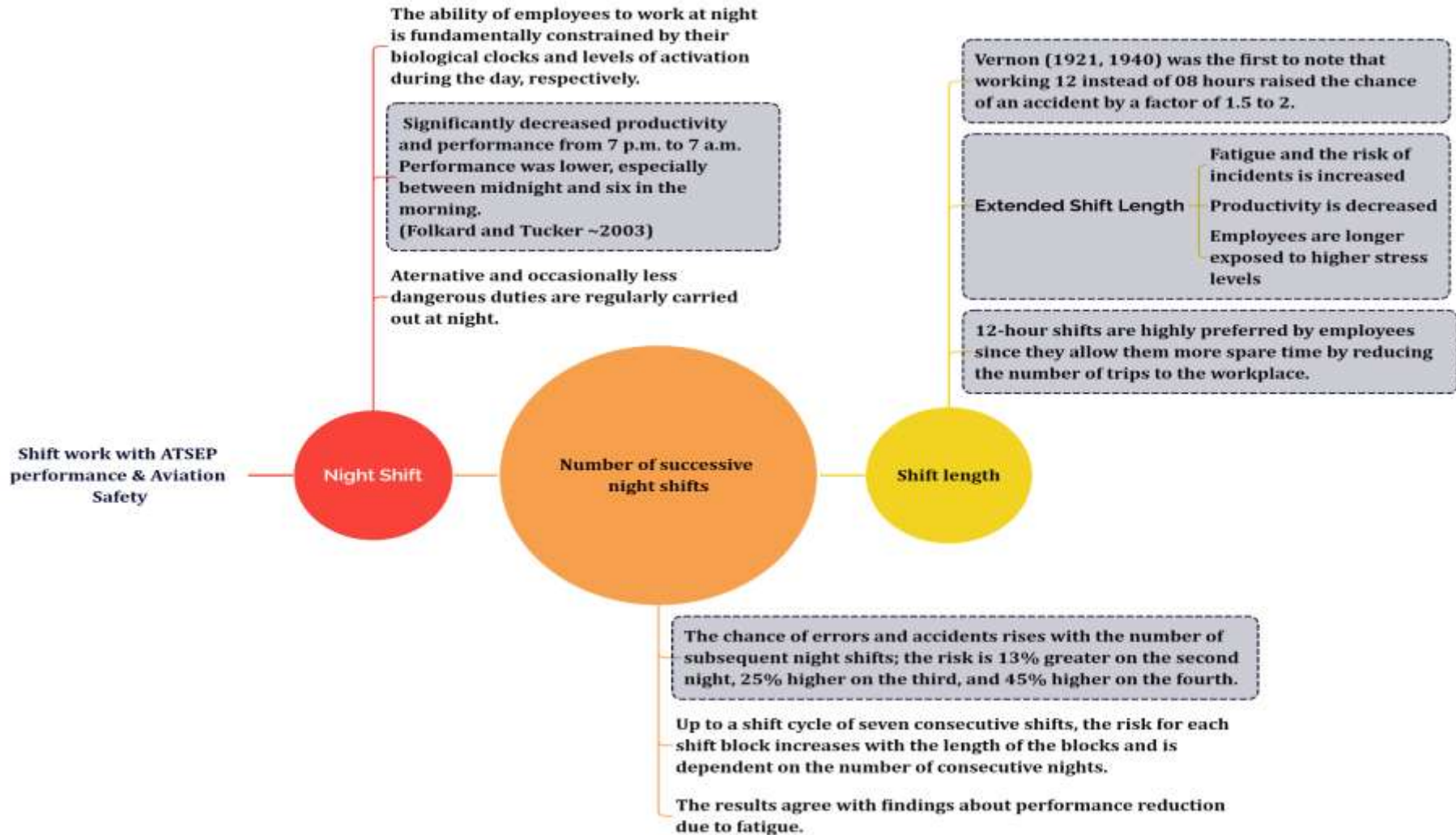


Figure 10: Shift work with ATSEP Performance and Safety

4.5.5. Guideline 5 - Shift rotation pattern

Unfavourable shift sequences are supposed to be avoided. Forward rotation is preferable.

Explanation

- 1) According to ergonomic research, workers who rotate their shifts forward (early, late, and night shifts) experience less health problems than those who cycle their shifts backward (night, late, early, shift).
- 2) In systems with a forward rotation, the rest periods between shifts are typically longer.

4.5.6. Guideline 6 - Early shift

The early shift is not supposed to start too early.

Explanation

- 1) The early shift is not intended to be only a portion of the night shift. They must wake up at 3:30 in the morning to begin their shift at 5:30 in the morning because many employees today frequently have long commutes to work.
- 2) It has been observed that workers who work the early shift do not often retire much earlier. Many people also worry about not waking up on time.
- 3) This causes a significant sleep deficit, particularly in long-rotated systems.

4.5.7. Guideline 7 - Night shift length

Night shifts should finish as early as possible.

Explanation

- 1) This advice is based on the discovery that the times of daytime sleep are related to the time of sleep onset.
- 2) The likelihood of sleeping for a longer period increases with earlier sleep onset.
- 3) Due to their body clocks, most employees awake around midday after night shift.
- 4) The length of their sleep varies depending on when they first fell asleep.

4.5.8. Guideline 8 - Concentration of working hours restriction

The concentration of working days or working hours on one day is supposed to be restricted.

Explanation

- 1) Experience has shown that shift arrangements with a significant amount of free time are quite appealing to the workers.
- 2) The concentration required during work hours must be sacrificed to have extended periods of free time.
- 3) Many shifts must be completed without a break on days off to obtain extensive free leisure periods.

4.5.9. Guideline 9 - Notification of rosters

- 1) Employers must provide the roster at least seven days' advance.
- 2) Prior to the start of a shift, an employer must give employees at least 48 hours' notice of the start time due change in roster.
- 3) Employees should receive financial compensation if prior notice is not possible with at least 48 hours' notice.

4.5.10. Guideline 10 - Rest in Night Shift / Single Shift

- 1) An employee shall be allowed periods of rest from operational duties in accordance with occupational health and safety principles (fatigue risk management assessment and screen-based work).
- 2) The ANSP shall monitor the occupational health and safety element of shift lengths and operational duty requirements for the provision of breaks on safety and risk assessments in circumstances when only single-person staffing is offered or on night shifts

4.5.11. Guideline 11 - Emergency Duty

- 1) Emergency Duty: employees may be required to work emergency duty, that is, work in circumstances where they are recalled working to meet an emergency at a time when the employee would not ordinarily have been on duty and notice of which was not given prior to an employee's ceasing duty on the previous shift. Proper rest should be given to the employee.

4.6. References

- 1) The circadian rhythm in balance (parans.com).
- 2) Manipulating the sleep-wake cycle and circadian rhythms to improve clinical management of major depression | BMC Medicine | Full Text (biomedcentral.com).
- 3) Human Factor of ATSEP.
- 4) IFATSEA Mastermind group discussion.
- 5) ICAO Asia Pacific meeting for preparation of human factors guidance material for ATSEP.

APPENDIX 5 MEASURES DURING PANDEMIC

5.1. Introduction

Coronavirus disease, often known as Covid-19, is an infectious & contagious disease, which took the world in its grip like a wildfire. The virus (Corona Virus) was initially discovered in 2019. Covid-19 was declared a global pandemic by the World Health Organization in March 2020. True to the nature of Pandemics, Covid-19 swept the Civil aviation off its feet and in turn threatened to destroy the world economy by sheer disruptive impact. No doubt that, it was a devastating year for the aviation industry. Since then, the International Civil Aviation has been trying to limp back to normalcy. Considering the current dependence of world economy on aviation, it can be safely said that the sooner Civil Aviation acquires normalcy the better it will be for Global economy. However, seeing the crisis from only Economic perspective and ignoring the Human angle may generate a wrong perception. Such erroneous perception may lead to mitigation methods that are bereft of Human factors.

The Civil aviation is supported by the Pilots, ATCOs, AMEs and the common binding force connecting all of them: the ATSEP. That there should be measures taken to preserve this workforce to enable it to operate at full efficiency and in turn ensure Safe, Timely and Efficient Civil Aviation. We must also consider the fact that Covid-19 may not be the last pandemic to hit mankind. That means that we must be on a lookout for the minute symptoms and remain in a state of preparedness to ensure that the Covid- induced glitch remains an isolated phenomenon.

5.2. Backdrop of the Paranoia: Fear psychosis behind Covid- 19

In the case of COVID-19, it has been a suffering on the part of ANSPs and the ATSEP as well. Whereas for ANSPs the pandemic has meant considerable loss on the economic front as well as on the Personnel front. So many precious lives have been lost and many others have been scarred for life.

1. Fear of Contracting the Disease while performing Operational duties. To cover the Medical, Cargo, Repatriation flights ATSEP had to be on active duty, however the atmosphere of fear was always there.
2. Airline staff/ Traffic hands coming with Physical FPL, NOTAM Broadcast messages etc. This is an interaction which has been unavoidable due to the existing methods of operation. But at the same times, such methods mean that the Covid-19 protocols were to be ignored at times.
3. Being alone on duty- No one to share load/ feelings etc, giving rise Negative Emotions & thoughts. ANSPs resorted to Single person duty to ensure maximum Physical separation. However, this move resulted in personnel performing duties alone and hence battling negative emotions.
4. Worry about risk to family members. Every operational duty person was worried about the possible risk to family members especially when the Office atmosphere was not totally risk free.
5. Reduction in Opportunity for knowledge/ skill enhancement- especially in Classroom environment. Technical personnel are more used to classroom trainings and physical interaction with Instructors/ Mentors.

6. Reduction in Salary and continuous fear of Layoffs. ANSPs in general opted for reducing the salary of the staff to cut the losses in view of the economic slowdown arising out of State enforced lockdown and Pandemic situation.
7. Delay in Arrangement of Sanitization, Arrangement of Vaccines despite being Frontline workers. ATSEP functioned as frontline workers during Pandemic. But when vaccinations were being arranged, the frontline worker tag was conveniently taken away.

5.3. The Mitigation measures to be taken during Pandemic.

1. Provision of Adequate and quality preventive measures at Offices (Sanitizers, masks, PPE etc). A happy and confident worker is an efficient worker. Immediate address of safety concerns of ATSEP with respect to contracting disease on duty can be mitigated and services be utilised in efficient manner.
2. Technical strive to reduce handling of physical papers, this will ensure suitable follow of Covid-19 protocol which very clearly mentions maintaining Physical distancing.
3. Raising Awareness among ATSEP by displaying Posters with messages, Dos/ Don'ts etc. By suitable display of Placards/ posters, the ATSEP can be educated about the methods to keep oneself safe and free from the disease.
4. Ensure Clean & hygienic Office Environment. A clean and hygienic office atmosphere can go a long way in ensuring mitigation of any pandemic be it Covid or any other in future.
5. Pre-order sufficient Sanitizers, masks etc. By ensuring proper and sufficient supply of preventive supplies, fear psychosis can be dealt with.
6. Regular and mandatory Counselling Sessions for ATSEP. Though posters and placards help to educate the personnel, it is required to carry out regular counselling of ATSEP regarding the preventive methods.
7. Active engagement of Non-Operational staff in monitoring the situation & liaison with state/ medical organizations. Coordination with the National level Medical Organizations
8. Consider whether a Face-to-Face meeting is must or Teleconference could be sufficient.

5.4. The future course of Action

The pandemic struck and wreaked havoc all around. Now what?? We need to embark on a continuous process to mitigate and to remain prepared for any such Pandemic- like situation that may occur in future.

1. Assessing the priorities within the aviation sector. The ANSPs need to set the priorities right. In the event of any future Pandemic, the ANSP must prioritize the Physical and Mental health of the ATSEP. This will be a win-win situation for both- ATSEP and ANSP. As the ANSP would be able to sustain the critical operations by ensuring Physical and Mental well-being of the ATSEP. Since the maintenance of CNS-ATM systems is the prime responsibility of ATSEP, effort should be made to minimize the exposure of ATSEP to risky environment in Pandemic situation.

2. Identifying human factors and human performance related risks. Pandemic like situations tend to leave permanent scars in the mind of the survivors. It may also result in loss of confidence of the personnel who have gone through these situations. It is important to address such issues by carrying out confidence building methods.
3. Identifying potential indicators for monitoring the COVID-19 situation and Monitoring of occurrences and trends. Proactive monitoring may be a domain of the State health agencies, but by suitable liaising with the State agencies, the preparedness condition can be enhanced.
4. Reporting systems and documenting lessons learned. Once the effect of Pandemic has been dealt with, it becomes especially important to prepare for any such eventuality in future. The pandemic has taught many humane values and critical lessons. These must be incorporated in Human factor considerations.
5. Planning for the restart of operations. This step involves many sub-plots that work towards ensuring a proper restart of aviation after the ill effects of the pandemic:
 - Design a restart/ relaunch framework.
 - Take steps to build confidence among the end users and the technical experts (ATSEP).
 - Safeguarding the health of personnel.
 - Review of the demand-supply chain. How much to start full-fledged and how much to operate at a degraded level.
 - Handling the restart with a Human touch.
 - Sustaining the values learnt from pandemic crisis and planned investing in recovery.

5.5. References

1. Human factors of ATSEP: Factors & Countermeasures.
2. <https://www.icao.int/covid/cart/Pages/CART-Take-off.aspx>
3. Brainstorming sessions of Mastermind group.
4. Brainstorming sessions of APAC workgroup of HF guidance material preparation.

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APPENDIX 6 PROGRESSIVE TRAINING

6.1. Introduction

ATSEP (Air Traffic Safety Electronics Personnel) is the recognized terminology used for personnel competent in the installation, operation, and maintenance of a CNS/ATM system. ATSEP are those technical specialists working to provide and support the electronics and software which enable ATS systems to function. ATSEP comprise engineers, technicians, and computer hardware and software specialists who are responsible for the specification, procurement, installation, calibration, maintenance, testing and certification of ground electronic systems used to help control aircraft movements. ANSP has the responsibility to define the scope of ATSEP activities and it must be approved by appropriate authority. A competency-based training and assessment program for ATSEP has already been established which is recommended for the training of ATSEP by ANSPs. Lately Aviation fraternity has taken cognizance of the role played by ATSEP in delivering safety and of their role in the safety chain. At a time of increasing complexity of the air traffic system, it is important to minimise the risk arising from technical and engineered systems, and to ensure their correct functioning.

In this context, ICAO has specific documents recommended for preparation of CBTA training material for ATSEP namely Doc 9868 (PANS- TRG) and Doc 10057 (Manual of ATSEP CBTA). ANSPs are expected to design ATSEP training programs based on the above referenced Docs.

6.2. Background of ATSEP training

1. The scope of activities performed by ATSEP is of a wide variety: knowledge skills and aptitude required in fields of Electronics, Computers, and network, however not limited to these. At the same time level varying from Technician to maintenance engineer and going up to High level engineering. Working in such varied CNS/ATM systems requires a wide Range of competencies and expertise.

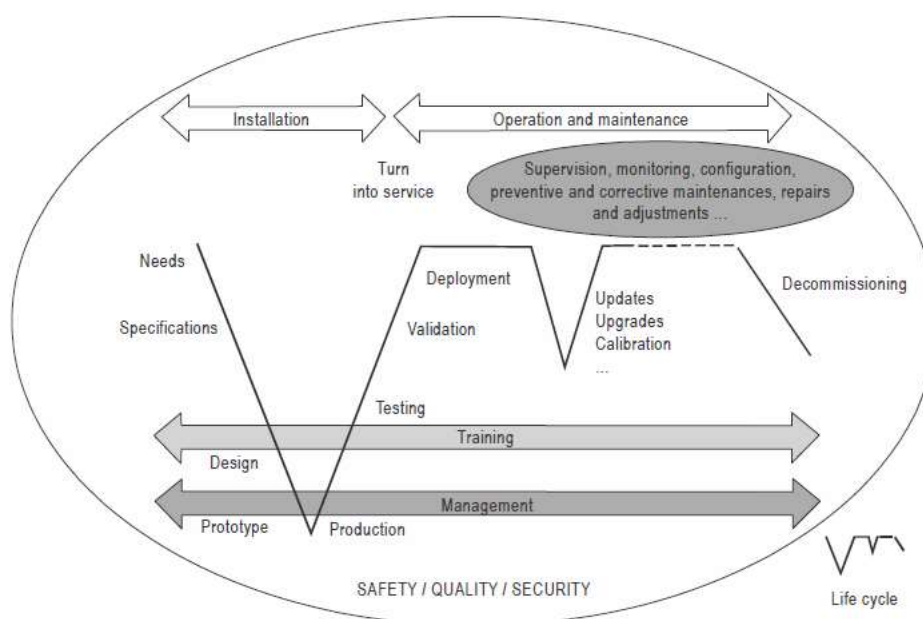


Figure 11: Scope of ATSEP activities

- The Training Phases of ATSEP can be organized into five phases namely: Selection, Initial Training, Unit Training, Continuation training, and Development training.

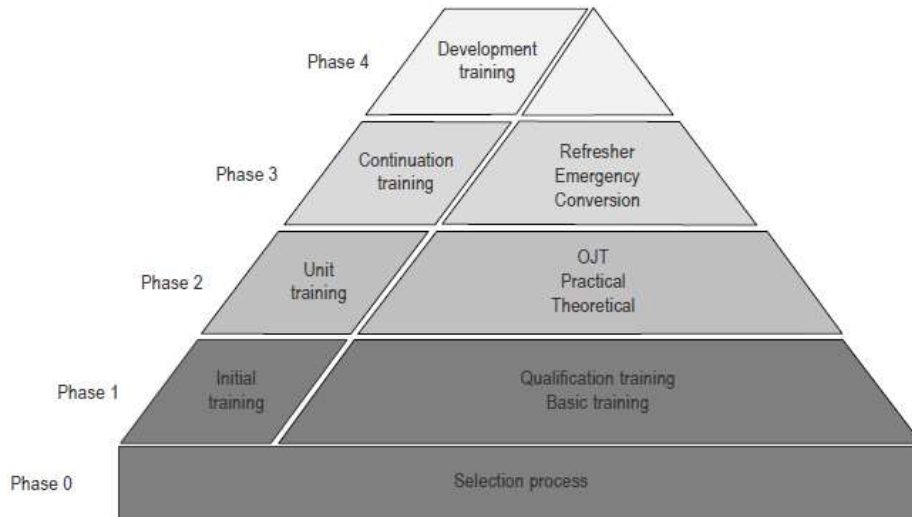


Figure 12: ATSEP training phases

- The ATSEP training path and its progression is also well taken care of by the Doc 10057. It defines the training requirements in the event of Change within the system; Change of domain; Change of activities, and inclusion of any additional system. The ATSEP training progression can be depicted through the appended figure.

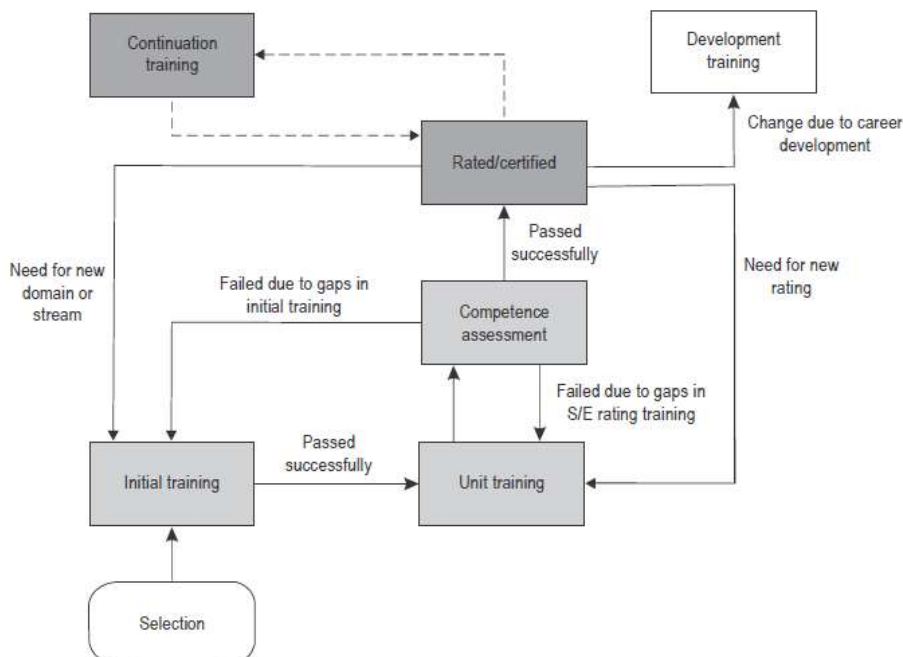


Figure 13: ATSEP training progression

6.3. The Roadblocks to complete adoption of the Docs 9868 & Doc 10057

1. Trainee is required to be taken out from normal duties for imparting training.
2. Exorbitant Training Cost in terms of infrastructure and training Man-hours as well.
3. Maintenance perils of Training on live equipment (at centres other than Dedicated training Centres).
4. Communication gap between ATSEP, ATCO and Pilot in terms of facilities being available for Operation or withdrawn for training purposes.
5. Lack of awareness regarding Airborne equipment and its functions.
6. Maintain the competency by continuous assessment and measurement of the performance criteria

6.4. How can these roadblocks be addressed?

1. Simulation and real-life based experiments with the live systems.
2. Build a repository of questionnaire and update frequently to have a training infrastructure which is not system- dependent.
3. Maintaining centralized general log and fault logs.
4. System wide information management- Access to all kinds of information from OEM to all levels of ATSEP i.e., CNS/ATM system issues from installation to commissioning, operational and maintenance issues, faults, and their solutions. Seamless access to procedures, standards, and recommendations of CNS/ATM related information.
5. ATSEP should have a knowledge of ATM operational environment and the exact application of facilities being provided.
6. Unit level training on operational equipment and on a backup system.
7. Collection and analysis of the system logs from time to time.
8. Refresher courses and proficiency checks.

6.5. References

1. DOC 10057 Manual on Air Traffic Safety Electronics Personnel Competency-based Training and Assessment.
2. Doc 9868 - PROCEDURES FOR AIR NAVIGATION SERVICES – Training
3. Brainstorming sessions of APAC workgroup of HF guidance material preparation
3. Brainstorming sessions of Mastermind group.

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APPENDIX 7 STRESS MANAGEMENT

7.1. Introduction

Stress is the psychological and physical state that results when the resources of the individual are not sufficient to cope with the demands and pressures of the situation. Thus, stress is more likely in some situations than others and in some individuals than others. Stress can undermine the achievement of goals, both for individuals and for organizations.

Stress at workplace, changes in the work environment has led to a change in the balance between physical and mental activity. Technological developments have reduced the amount of heavy physical work. Mental and emotional strain have increased in new working environments that are characterized by lack of time, more uncontrollable factors, background distractions, lack of space, general uncertainty, and more administrative work.

Stressors are the agents which trigger the various stress reactions. Today's environment provides physical, emotional, and mental stressors that set off the initial alarm reaction. Physical stressors in factories are usually linked to noise and physical and chemical hazards. Emotional or mental stressors can be unpleasant or pleasant. A promotion can be just as stressful as the loss of a position. Stressors are additive and can build up. The way in which people are affected depends on their values, experience, and adaptability. A single stressor can become compounded if elements of the established support system fail—for example, if a car breaks down on the way to an important meeting.

7.1.1. Process of stress – Three stages

7.1.1.1. Alarm reaction

This is the immediate response to a challenge or threat. Mobilisation of the autonomic nervous system triggers the stress response ("fight or flight" response). The various body systems involved coordinate the readiness for action, influencing mood (limbic system), the regulation of the cardiovascular system, breathing, muscle tension, and fine motor activities.

7.1.1.2. Resistance stage

The alarm reaction cannot be maintained indefinitely, and longer exposure to stressors causes people to reach the resistance stage. In this phase people develop a "survival" strategy and a way of fighting against the response the stressor has initiated. Coping mechanisms may be adequate or inadequate. People tend to prefer short term relief to long term solutions and try to escape uncomfortable situations with a quick remedy. Unfortunately, most easy, short-term measures are inadequate because they usually lead to secondary problems such as long-term reduction in performance. People need help to identify measures that can lead to long term benefit.

7.1.1.3. Exhaustion stage

The stress response is healthy in origin and is necessary to keep a person motivated and adaptable. It is when the demands on body and mind are too high or cannot be met in an appropriate way that the person becomes "distressed." Prolonged stress can lead to chronic problems, an exhaustion of all reserves and energies and even frank depression.

7.1.2. Causes of stress at working situations

Stress is often related directly to the job specifications and working environment or to relationships with people at work, or a combination of both. Conflicts with managers, subordinates, or colleagues may increase as work becomes more pressured. Smaller workforces are expected to do the same or more work, and there is a widespread lack of training in communication and interpersonal skills. Some of the stress also relates to the identification of a person's role.

7.1.2.1. Stressors in the working environment

- Uncertainty and lack of control (low job discretion)
- Lack of support from others including co-workers
- Extreme demands of working environment-long hours, high responsibility, commitment
- Extremely low demands leading to boredom, lack of meaning in work.
- Workstation-noise, poor lighting, lack of space, extreme temperatures poor ergonomics
- Chemical hazards, fumes, passive smoking
- Repetitive tasks

7.1.3. Consequences of stress*Table 4: Consequences of Stress*

Physical disorders	Emotional disorders	Mental dysfunction
Tension headaches, migraines irritable bowel syndrome Impaired resistance-Colds and other "viral" illnesses Potentiation of asthma, dermatitis, psoriasis, backache "Gastritis" High blood pressure	Depression Suicidal ideation Anxiety syndrome	Accidents or near accidents Loss of clarity of thought Reduced performance Difficulty in concentrating- "Small" but important things are forgotten or misled. Increase in mistakes and excuses. Increase in misunderstandings at work and at home. Sudden loss of short-term memory

7.1.4. Symptoms of Stress

Table 5: Symptoms of Stress

Frequent headaches, jaw clenching or pain Gritting, grinding teeth. Stuttering or stammering Tremors, trembling of lips, hands. Neck ache, back pain, muscle spasms Light headedness, faintness, dizziness Ringing, buzzing or “popping sounds. Cold or sweaty hands, feet Dry mouth, problems swallowing Frequent colds, infections, herpes sores Rashes, itching, hives, “goose bumps”. Unexplained or frequent “allergy” attacks Heartburn, stomach pain, nausea Constipation, diarrhoea, loss of control Difficulty breathing, frequent sighing. Sudden attacks of life-threatening panic Chest pain, palpitations, rapid pulse Frequent urination Social withdrawal and isolation Constant tiredness, weakness, fatigue Frequent use of over-the-counter drugs Weight gain or loss without diet Increased smoking, alcohol, or drug use Excessive gambling or impulse buying	Excess anxiety, worry, guilt, nervousness Increased anger, frustration, hostility Depression, frequent or wild mood swings Increased or decreased appetite Insomnia, nightmares, disturbing dreams Difficulty concentrating, racing thoughts. Trouble learning added information. Forgetfulness, disorganization, confusion Difficulty in making decisions. Feeling overloaded or overwhelmed Frequent crying spells or suicidal thoughts Feelings of loneliness or worthlessness Little interest in appearance, punctuality Nervous habits, fidgeting, feet tapping. Increased frustration, irritability, edginess Overreaction to petty annoyances Increased number of minor accidents Obsessive or compulsive behaviour Reduced work efficiency or productivity Lies or excuses to cover up poor work. Rapid or mumbled speech Excessive defensiveness or suspiciousness Problems in communication, sharing

7.2. Stress Management

There are known effective ways how the stress can be managed. However, everyone cannot handle the stress in the same manner as their personality differs from that of the others. Let us discuss these points and the benefits of the active stress management further.

7.2.1. Human Nature and Individual Differences

Personality psychology is partly about what makes everyone the same and partly about what makes people differ from each other. That is, personality theories are partly statements about human nature. Of the great many viewpoints that have been taken on human nature, two appear particularly relevant to stress and coping i.e., biological models and goal-based models.

Personality also concerns individual differences. Individual differences can be found on any dimension imaginable, but the five-factors widely adopted as a consensual framework. The five factors are most labelled extraversion, neuroticism, agreeableness, conscientiousness, and openness to experience.

It will also be useful to have a sense of some of the ways in which people differ and expectations of how those differences may play a role in coping.

7.2.1.1. Human Nature

7.2.1.1.1. Biological Models

An increasingly influential perspective, not just in personality but in all of psychology, treats humans as biological entities. From this view, it is desirable to develop a clear understanding of the basic properties of animal self-regulation and of how those properties are manifested in human behaviour. We focus here on three properties: the tendency to approach desirable objects and situations (e.g., food), the tendency to avoid dangerous objects and situations (e.g., predators), and the capacity to regulate the approach and avoidance tendencies.

Biological models assuming approach and avoidance temperaments have acquired a good deal of influence over the past decade. They hold that approach and avoidance systems are supported partly by distinct brain areas, and that the sensitivity of each system (which varies among persons) influences behaviour in response to environmental reward and threat cues.

Effortful control can override impulses stemming from the approach and avoidance systems. It acts as a supervisory system, provided sufficient mental resources are available. This confers many advantages, including constraining emotions and permitting the organism to plan and take situational complexities into account in behavioural decisions. Effortful control is a construct from developmental psychology, but its features closely resemble those of adult self-control: the ability to override impulses to act and the ability to make oneself undertake or persist in difficult, uninteresting, or unpleasant tasks.

Approach and avoidance systems, together with a supervisory system able to reorder the priorities they pursue, form the core of a biological model of human nature. They also form the core of a conceptually distinct but complementary view of human nature.

7.2.1.1.2. Goal-based models

From this perspective, knowing a person means knowing the person's goals and values and the relations among them. In goal-based theories, it is important to distinguish between motivational processes aimed at moving toward goals and those aimed at staying away from threats.

A desired goal has a positive incentive value that pulls behaviour to it. Looming harm or pain has a negative incentive value that pushes behaviour away from it. Sometimes only approach or avoidance is engaged. Sometimes they conflict, as when moving toward a goal also increases possibility of harm. Sometimes they work together, as when attaining a desired goal simultaneously forestalls something the person wants to avoid. Goal-based models also typically incorporate an expectancy construct: a sense of confidence or doubt that a given outcome will be attained successfully.

People sometimes give up or scale back on goals they have been pursuing. It is sometimes important to relinquish goals, though the process of doing so involves feelings of sadness and despair. An alternative to giving up is scaling back. This is disengagement in the sense that the initial goal is no longer operative. It avoids complete disengagement, however, by substituting the more restricted goal. This accommodation thus keeps the person involved in that area of life, at a level that holds the potential for successful outcomes.

Issues of goals and threats are important to understanding the structure of stressors. Issues of goal engagement and disengagement are important to understanding the structure of coping, as are issues of positive and negative expectancies for the future.

7.2.1.2. Individual Differences

7.2.1.2.1. Extraversion

As is true of several traits, extraversion has different emphases in different measures. Sometimes it is based in assertiveness, sometimes in spontaneity and energy. Sometimes it is based in dominance, confidence, and agency, sometimes in a tendency toward happiness. Extraversion is often thought of as implying sociability.

7.2.1.2.2. Neuroticism

The second factor, neuroticism, concerns the ease and frequency with which a person becomes upset and distressed. Moodiness, anxiety, and depression reflect higher neuroticism. Measures often include items or facets pertaining to hostility and other negative feelings, but they are dominated by vulnerability to experiences of anxiety and general distress. Neuroticism has been linked to the avoidance temperament discussed above, suggesting that anxiety and sensitivity to threat is indeed its emotional core.

7.2.1.2.3. Agreeableness

Agreeable people are friendly and helpful, empathic, and able to inhibit their negative feelings. Agreeable people get less angry over others. At the opposite pole is an oppositional or antagonistic quality. People low in agreeableness use displays of power to deal with social conflict. Agreeableness as a dimension is often characterized as being broadly concerned with the maintaining of relationships.

7.2.1.2.4. Conscientiousness

Agreeableness and conscientiousness share an important property. Both suggest breadth of perspective. Many manifestations of conscientiousness imply broad time perspective: taking future contingencies into account. Agreeableness implies a broad social perspective: taking the needs of others into account.

7.2.1.2.5. Openness to experience

It involves curiosity, flexibility, imaginativeness, and willingness to immerse oneself in a typical experience.

7.2.2. Relations Between Personality and Coping

People respond to perceptions of threat, harm, and loss in diverse ways. Coping is often defined as efforts to prevent or diminish threat, harm, and loss, or to reduce associated distress.

Extraversion, grounded in an approach temperament, involves sensitivity to reward, positive emotions, sociability, assertiveness, and high energy. Strong approach tendencies and assertiveness should provide the energy required to initiate and persist in problem; positive affect should facilitate cognitive restructuring; and an orientation toward others and access to a social network should facilitate social support coping.

Neuroticism, grounded in an avoidance temperament, reflects tendencies to experience fear, sadness, distress, and physiological arousal. Given this vulnerability to distress, neuroticism should lead to emotion-focused coping and disengagement from threat. Disengagement may be reinforced through short-term relief of distress this relief may reduce motivation to return to the stressor, thus minimizing engagement coping. Furthermore, the mere presence of intense emotional arousal can interfere with the use of engagement strategies that require careful planning. Negative affect should also make positive thinking and cognitive restructuring difficult.

Agreeableness involves elevated levels of trust and concern for others. Because those high in agreeableness tend to have strong social networks, agreeableness may predict social support coping. Openness to experience involves the tendency to be imaginative, creative, curious, flexible, attuned to feelings, and inclined toward new activities and ideas. These tendencies may facilitate engagement coping strategies that require considering new perspectives, such as cognitive restructuring and problem solving, but may also facilitate use of disengagement strategies such as dreaming.

Optimism involves the expectation of good outcomes and an engaged approach to life, reflecting the belief that good outcomes require some effort. These characteristics suggest that optimism will relate positively to engagement types of coping, such as problem solving and cognitive restructuring, and inversely to avoidance or disengagement coping. Pessimism involves the expectation of bad outcomes, which should promote distress and disengagement coping.

7.2.3. Benefits of active stress management

If you are living with elevated levels of stress, you are putting your entire well-being at risk. Stress wreaks havoc on your emotional equilibrium, as well as your physical health. It narrows your ability to think clearly, function effectively, and enjoy life.

Effective stress management, on the other hand, helps you break the hold stress has on your life, so you can be happier, healthier, and more productive. The goal is a balanced life, with time for work, relationships, relaxation, and fun—and the resilience to hold up under pressure and meet challenges head on.

7.2.4. Steps involved in the minimization of the stress.

7.2.4.1. Identify the sources of stress in your life.

Stress management starts with identifying the sources of stress in your life. This is not as straightforward as it sounds. While it is easy to identify major stressors such as changing jobs, moving, or a going through a divorce, pinpointing the sources of chronic stress can be more complicated. It is all too easy to overlook how your own thoughts, feelings, and behaviours contribute to your everyday stress levels. Sure, you may know that you are constantly worried about work deadlines, but it is your procrastination, rather than the actual job demands, that is causing the stress. A stress journal can help you identify the regular stressors in your life and the way you deal with them. Each time you feel stressed; keep track of it in your journal. As you keep a daily log, you will begin to see patterns and common themes.

7.2.4.2. Address the unhealthy coping strategies.

Think about the ways you currently manage and cope with stress in your life. Your stress journal can help you identify them. Ensure your coping strategies healthy and helpful. If any of the following is a stress coping strategy of yours, then it is neither healthy nor helpful. Smoking, using pills or drugs to relax, drinking too much, withdrawing from friends, family, and activities, Procrastinating, sleeping too much and taking out your stress on others. If your methods of coping with stress are not contributing to your greater emotional and physical health, it is time to find healthier ones. No single method works for everyone or in every situation, so experiment with different techniques and strategies. Focus on what makes you feel calm and in control.

7.2.4.3. Managing predictable stressors

While stress is an automatic response from your nervous system, some stressors arise at predictable times your commute to work, a meeting with your boss, or family gatherings, for example. When handling such predictable stressors, you can either change the situation or change your reaction. When deciding which option to choose in any given scenario, it is helpful to think of the avoid, alter, adapt, or accept.

7.2.4.3.1. Avoid unnecessary stress.

It is not healthy to avoid a stressful situation that needs to be addressed, but you may be surprised by the number of stressors in your life that you can eliminate. Know your limits and stick to them. Distinguish between the "should" and the "musts". Drop tasks that are not necessary to the bottom of the list or eliminate them entirely. Avoid people who stress you out. Take control of your environment.

7.2.4.3.2. Alter the situation.

If you cannot avoid a stressful situation, try to alter it. Often, this involves changing the way you communicate and operate in your daily life. Express your feelings instead of bottling them up. Be willing to compromise. Try to find a balance between work and family life, social activities and solitary pursuits, daily responsibilities, and downtime.

7.2.4.3.3. Adapt the stressor.

If you cannot change the stressor, change yourself. You can adapt to stressful situations and regain your sense of control by changing your expectations and attitude. Try to view stressful situations from a more positive perspective. Take perspective of the stressful situation. Set reasonable standards for yourself and others.

7.2.4.3.4. Accept the things you cannot change.

Some sources of stress are unavoidable. You cannot prevent or change stressors such as the death of a loved one, a serious illness, or a national recession. In such cases, the best way to cope with stress is to accept things as they are. Acceptance may be difficult, but overall, it is easier than railing against a situation you cannot. Do not try to control the uncontrollable instead focus on the things you can control. When facing major challenges, try to look at them as opportunities for personal growth. Learn to forgive. Talk to a trusted friend or make an appointment with a therapist.

7.2.4.4. Manage time and schedules.

Poor time management can cause a lot of stress. When you are stretched too thin and running behind, it is hard to stay calm and focused. Do not over-commit yourself. Prioritize tasks. Break projects into small steps. Delegate responsibility. Maintain balance with a healthy lifestyle. Eat a healthy diet. Reduce caffeine and sugar. By reducing the amount of coffee, soft drinks, chocolate, and sugar snacks in your diet, you will feel more relaxed, and you will sleep better. Avoid alcohol, cigarettes, and drugs. Self-medicating with alcohol or drugs may provide an easy escape from stress, but the relief is only temporary. Do not avoid or mask the issue at hand, deal with problems head on and with a clear mind. Get enough sleep. Adequate sleep fuels your mind, as well as your body. Feeling tired will increase your stress because it may cause you to think irrationally.

7.2.5. Assistance under stressful situation

The best way to get assistance from others under stressful situations is to have better connection with others. There is nothing more calming than spending quality time with another human being who makes you feel safe and understood. In fact, face-to-face interaction triggers a cascade of hormones that counteracts the body's defensive "fight-or-flight" response. Its nature's natural stress reliever, it also helps stave off depression and anxiety. So, make it a point to connect regularly and in person with family and friends.

Keep in mind that the people you talk to do not have to be able to fix your stress. They simply need to be good listeners. And try not to let worries about looking weak or being a burden keeps you from opening. The people who care about you will be flattered by your trust. It will only strengthen your bond. Of course, it is not always realistic to have a friend close by to lean on when you feel overwhelmed by stress, but by building and

maintaining a network of close friends you can improve your resiliency to life's stressors.

Some of the tips for building relations through which the assistance can be obtained or offered during the stressful situation. Reach out to a colleague at work, help someone else by volunteering, have lunch or coffee with a friend, ask a loved one to check in with you regularly, accompany someone to the movies or a concert, Call or email an old friend, go for a walk with a workout buddy, Schedule a weekly dinner date, meet new people by taking a class or joining a club, Confide in a clergy member, teacher, or sports coach.

7.2.6. Effects of shocking and stressful situation

A critical incident is any situation that causes a person to experience unusually strong stress reactions that the person perceives as disturbing or disabling.

Few examples of such traumatic events are, earth quacks, tsunamis, aviation accidents, terrorism, major air traffic collision, failed rescue attempts, hostages type events.

Critical incidents produce characteristic sets of psychological and physiological reactions or symptoms (thus the term syndrome) in all people, including emergency service personnel. Typical symptoms of Critical Incident Stress include Restlessness, Irritability, Excessive Fatigue, Sleep Disturbances, Anxiety, Startle Reactions, Depression, Moodiness, Muscle Tremors, Difficulties, Concentrating, Nightmares, Vomiting, Diarrhoea and Suspiciousness.

The physical and emotional symptoms, which develop as part of a stress response, are normal but have the potential to become dangerous to the responder if symptoms become prolonged.

Signs of Critical Incident Stress as per Centre for Disease Control of USA are given below.

Table 6: Signs of Critical Incident Stress

Physical	Cognitive	Emotional	Behavioral
Fatigue	Uncertainty	Grief	Inability to rest
Chills	Confusion	Fear	Withdrawal
Unusual thirst	Nightmares	Guilt	Antisocial behavior
Chest pain	Poor attention	Intense anger	Increased alcohol
Headaches	Poor concentration	Apprehension	consumption
Dizziness	Poor memory	Depression	Change in communications
	Poor problem solving	Irritability	Loss/increase in appetite
	Poor decision-making ability	Chronic anxiety	

7.3. References

DOC 10057 (Second edition) - Recommended training objectives for a basic training course, Subject 15 – Human Factors, Topic – 7 – Stress.

APPENDIX 8 SAFETY CULTURE

8.1. Introduction

8.1.1. Safety Importance in Aviation

Safety and security are of paramount importance in aviation. A safe aviation system contributes to the economic development of states and their industries. For all ANSPs regardless of whether they are operated by a state or by a commercial organisation, safety must come first when delivering Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM) services. In the present technology centric air-ground CNS/ATM systems, ATSEP role in the safety chain is crucial to seal all the holes in the last layer of defence.

8.1.2. Safety: The Foremost Strategic Objective of ICAO

Aviation safety is the fundamental objective of International Civil Aviation Organisation (ICAO). This strategic objective aims to enhance global civil aviation safety and focuses primarily on a state's effective safety oversight and its capabilities in the management of safety.

Aviation industries and service providers operate in an open system that remain exposed to many external variables which requires highly vigilant and constant monitoring to ensure that the higher levels of aviation safety can be realized. To offer this safety assurance, ICAO has mandated in November 2006 that all member states shall implement a formal Aviation Safety Management Systems (SMS).

Annex 19 of ICAO requires that both the states and service providers promote a positive safety culture with the aim of fostering effective safety management implementation through the SSP/SMS.

8.1.3. Safety Work Culture

Aviation safety work culture is the set of enduring values, behaviours, and attitudes regarding safety, shared by every individual at every level of an organization. It has been described as "how people behave in relation to safety and risk when no one is watching". Attitude, awareness, behaviour, commitment – these are the primary tenets of safety culture as these ensure safety success which-

- reflects the **attitudes** in an organization.
- needs safety **awareness** to be successful.
- is exemplified by **behaviour** of employees at all levels of an organization; and
- indicates future **commitment** and safety performance.

A safety culture is the natural consequence of having humans involved in the aviation system. It is an expression of how safety is perceived, valued, and prioritized by management and employees in an organization, and is reflected in the extent to which individuals and groups are:

- aware of the risks and known hazards faced by the organization and its activities.
- continuously behaving to preserve and enhance safety.
- able to access the resources required for safe operations.
- willing and able to adapt when facing safety issues.
- willing to communicate safety issues; and
- consistently assessing the safety related behaviours throughout the organization

8.1.4. Safety Culture and Safety Performance

Safety Culture has a direct impact on safety performance. Here are some ways to show how aviation safety culture leads directly to safety performance.

8.1.4.1. Quality safety culture entails considerate safety behaviour.

A safety culture is something that happens on an organizational level and as well as individual level. A successful and a quality aviation safety culture demonstrates a commitment to the aviation SMS.

What is difficult about safety behaviour is how to measure it. Consider the following as quantifiable and trackable ways of measuring safety behaviour, where each point requires specific action on the part of ATSEP and management to achieve safety success.

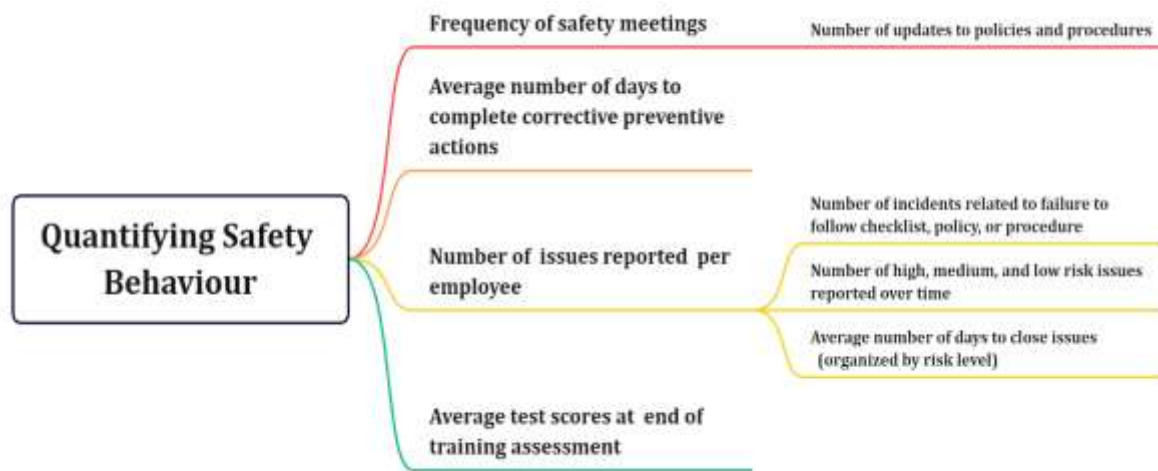


Figure 14: Quantifying Safety Behaviour

8.1.4.2. ATSEP perform even when not under safety supervision.

There can be two possibilities to check if management is not supervising the safety behaviours of ATSEP-

- The actions of the managerial authority when ATSEP are not under safety supervision of management? Or,
- The response of ATSEP when management is not watching.

In most organizations, individuals only loosely follow policies and procedures when management is not around. This is especially true when management does not take an active role in its relationship with front-line ATSEP.

One of the financial incentives in building a safety culture and thereby supervising the safety behaviour, besides saving money due to workplace injuries, is that ATSEP become more productive because their work is consistent. This productivity does not come at the cost of safety. Rather, ATSEP:

- are set back by safety issues less often.
- maintain working standards and adhere to organisation policy most of the time; and
- are better at monitoring and responding quickly to their work environment.

On the management side, managers can devote more time to important safety tasks, and less time for micromanaging employees and other managers. Good safety culture removes the burden of “authority” inherent in the top-down structure of aviation SMS implementations. Employees better manage themselves, and the top-down structure remains important for guidance rather than discipline.

8.2. Safety Culture Development and Benefits.

8.2.1. Developing A Positive Safety Culture.

A positive safety culture has the following features:

- managers and frontline ATSEP, individually and collectively, want to make decisions and take actions that promote safety.
- individuals and groups continually critique their behaviours, processes and welcome the critique of others searching for opportunities to change and improve as their environment changes.
- management and individuals share a common awareness of the hazards and risks faced by the organization and its activities, and the need to manage risks.
- individuals act and make decisions according to a common belief that safety is part of the way they do service and ensures safety.
- individuals value being informed, and informing others, about safety.
- individuals trust their colleagues and managers with information about their experiences, and the reporting of errors and mistakes is encouraged to improve how things are done in the future.

8.2.2. Safety Culture as Safety Enabler of Safety Management.

Safety values are incorporated into practices by management and personnel who directly affects how key elements of the State Safety Plan (SSP), and Safety Management System (SMS) are established and maintained. Therefore, safety culture has a direct impact on safety performance.

If someone believes that safety is not that important then workarounds, cutting corners, or making unsafe decisions or judgements may be the result, especially when the risk is perceived as low and there is no apparent consequence or danger.

The safety culture of an organization therefore significantly influences how their SSP, or SMS develops and how effective it becomes. If an organization has instituted all the safety management requirements but does not have a positive safety culture, it is likely to underperform.

When the organization has a positive safety culture, and this is visibly supported by upper and middle management, front-line ATSEP tend to feel a sense of shared responsibilities towards achieving the organization’s safety objectives. Effective safety management also supports efforts to drive towards an increasingly positive safety culture by increasing the visibility of management’s support and improving active involvement of personnel in managing safety risk.

8.2.3. Safety Work Culture benefits.

When leadership actively endorses safe practices, it becomes the normal way of doing things. The ideal situation is a fully implemented and effective SSP/SMS and a positive safety work culture. Hence, an organization’s safety culture is often seen as a reflection of the maturity of its SSP/SMS. Effective safety management empowers a positive safety culture, and a positive safety culture empowers effective safety management.

8.2.3.1. Safety work culture benefits in case of adoption in ATSEP domain.

- Safe, efficient, effective, and economic provision of Air Navigation Services
- Reduced incidents/injuries
- Increased productivity
- Reduced costs
- Supports safe environment and workplace ergonomics.

8.2.4. Benefits of Safety Management.

The advantage of having a positive safety work culture will invariably results in the benefits derived from implementation of the effective safety management system in any ANSP.

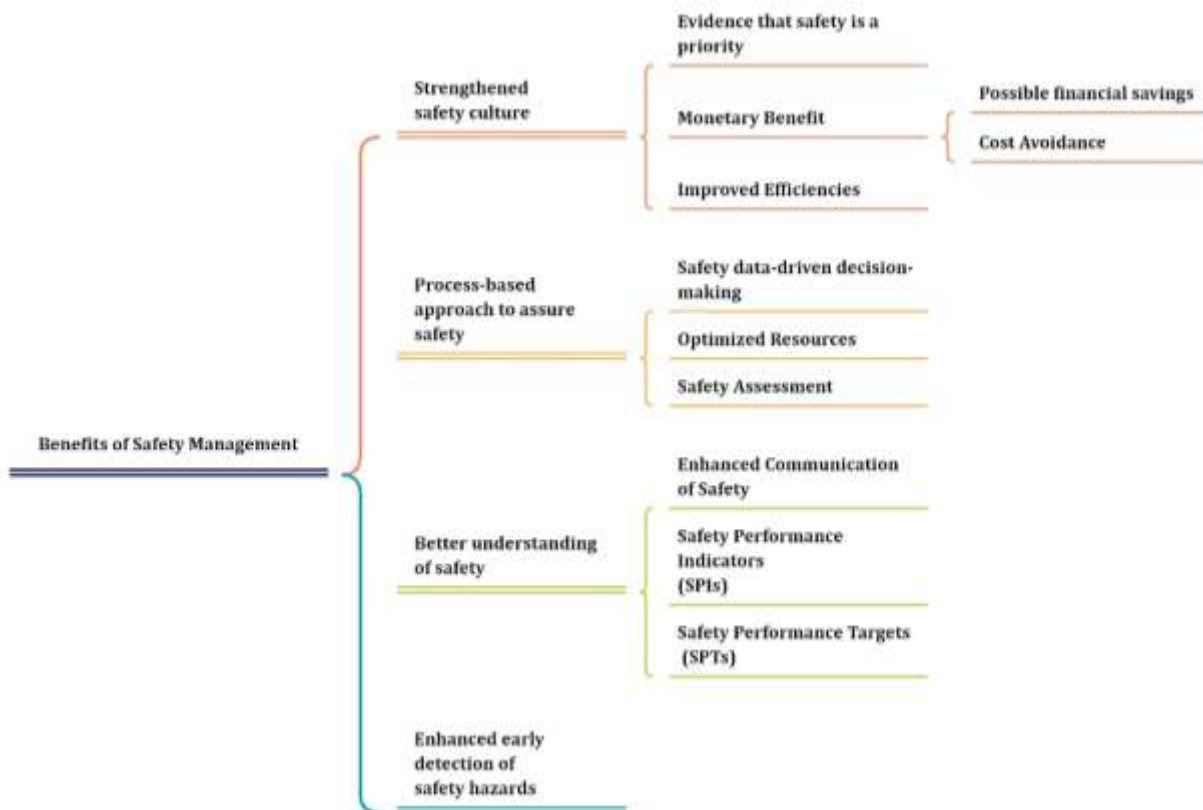


Figure 15: Benefits of Safety Management

8.2.5. Safety Culture Enablers and Disablers

Actions by management and employees can help drive their safety culture to be more positive. The following table provides examples of the actions of management and employee that will enable or disable a positive safety culture in an organization. Organizations should focus on providing enablers and removing any disablers to promote and achieve a positive safety culture.

Element and its General Description	Enablers	Disablers
Commitment to safety This reflects the extent to which senior management within the organization have a positive attitude towards safety and recognizes its importance. Senior management should be genuinely committed to achieve and maintain an elevated level of safety and give employees motivation and the means to do so also.	• Management leads safety culture and is actively motivating its employees to care for safety, not only by talking but by acting as role models • Management provides resources for a range of safety related tasks (e.g. training) • Continuous safety management oversight and governance is established	• Management is actively demonstrating that profit, cost reduction and efficiency come first. • Investments to improve safety are often made when required by regulations or after accidents • Neither oversight nor governance regarding safety management is established
Adaptability Adaptability reflects the extent to which employees and management are willing to learn from past experiences and can act necessary to enhance the level of safety within the organization.	• Employee input is actively encouraged when addressing safety issues • All incidents and audit findings are investigated and acted upon • Organizational processes and procedures are questioned for their safety impact (high extent of self-criticism) • A clear proactive approach to safety is demonstrated and followed.	• Employee input on safety issues is are not sought from all levels of the employees • Actions are often taken only after accidents or when required by regulations. Even when an accident occurs the organization is unwilling to question itself. • Organizational processes and procedures are considered adequate if no accident occurs (complacency or lack of self-criticism) • A reactive approach to safety is demonstrated and followed.

Element and its General Description	Enablers	Disablers
Awareness Awareness reflects the extent to which employees and management are aware of the aviation risks faced by the organization and its activities. From a state perspective, personnel are aware of both the safety risks induced by their own activities and the organizations they oversee. Employees and management should be constantly maintaining a high degree of vigilance with respect to safety issues.	• An effective way of hazard identification has been established • Investigations seek to establish the root cause. • The organization stays abreast of important safety improvements, and adapts itself accordingly as necessary • The organization systematically evaluates if safety improvements are implemented and working as intended. • Where appropriate, members of the organization are well aware of the safety risks induced by their individual actions and company operations / activities	• No effort is spent on hazard identification • Investigations stop at the first viable cause rather than seek the root cause • The organization does not stay abreast of important safety improvements • The organization does not evaluate if safety improvements are implemented properly. • Where appropriate, members of the organization are not aware of the safety risks induced by their individual actions and company operations • Safety data is gathered but not analysed and acted upon
Behaviour with respect to safety Behaviour with respect to safety reflects the extent to which every level of the organization behaves such as to maintain and improve the level of safety. The importance of safety should be recognized, and processes and procedures needed to maintain it should be put in place.	• The employees motivate themselves to act safely and by acting as role models • Continuous monitoring of safe behaviour is practised. • Intentional unsafe behaviour is not tolerated by management and colleagues • The working conditions support aviation safety at all times.	• No monitoring of aviation safety within the organization's products or services is practised. • Employees are not punished for intentional unsafe behaviour to the benefits of their own or other interests • The working conditions provoke behaviour and workarounds that are detrimental to aviation safety • It is not acceptable to offer constructive feedback that can improve aircraft safety.

Element and its General Description	Enablers	Disablers
Information Information reflects the extent to which information is distributed to all necessary people within the organization. Employees should be enabled and encouraged to report aviation safety concerns and receive feedback on their reports. Work information related to aviation safety must be communicated meaningfully to the right people to avoid miscommunication that could lead to hazardous aviation system situations and consequences. The State is open to share aviation safety related information to all service providers.	• An open and just safety reporting environment exists. • Employees are provided with safety-relevant information in a timely manner to allow for safe operations or decisions to be made. • Management and supervisors regularly check whether safety relevant information is understood and acted upon • Knowledge transfer and training about aviation safety is actively practiced (e.g., sharing of lessons learned)	• A blaming safety reporting environment is evident. • Safety-relevant information is withheld. • Safety communication is not monitored for its effectiveness • No knowledge transfer or training is provided.
Trust Employee contribution to safety thrives in a reporting environment that fosters trust – trust that their actions or omissions, commensurate with their training and experience, will not be punished. Such an environment is fundamental to effective and efficient safety reporting. Effective safety reporting systems help to ensure that people are willing to report their errors and experiences, so that States and service providers have access to relevant data and information that is necessary to address existing and potential safety deficiencies and hazards. These systems create an environment in which people can be confident that safety data and safety information will be used exclusively for improving safety.	• There is a distinction between acceptable and unacceptable behaviour, which is known to all the employees. • Occurrences (including accidents and incidents) investigations consider individual as well as organizational factors. • Good aviation safety performance is recognized and rewarded on a regular basis. • There is willingness among employees and operational personnel to report events in which they have been involved.	• There is no identifiable distinction between acceptable and unacceptable behaviour. • Employees are systematically and rigorously punished for human errors. • Accident and occurrence investigations focus on individual factors only. • Good safety performance and safe behaviour is taken for granted.

8.3. Safety Reporting and Just Culture

8.3.1. Safety Culture and its influence on Safety Reporting

SSPs and SMSs are sustained by safety data and safety information that is necessary to address existing and potential safety deficiencies and hazards, including safety issues identified by ATSEP. The success of a reporting system depends entirely on the continuous flow of information from, and feedback to, organizations and individuals. The protection of safety data, safety information and related sources is essential to ensure continued availability of information.

For example, in voluntary safety reporting systems, this may be realized through a system that is confidential, and not used for purposes other than maintaining or improving safety. The benefits are twofold. Often frontline ATSEP who are the closest to safety hazards, so a voluntary reporting system enables them to actively identify these hazards and suggest workable solutions. At the same time, the regulator or management can gather important safety information and build trust with the organizations or frontline ATSEP who are reporting the information.

States are expected to adopt laws to adhere to the provisions outlined in Annex 19 for the protection of safety data, safety information and related sources. In the case of a voluntary reporting system, confidentiality should be ensured, and the reporting system operated in accordance with safety protection laws.

Further, organizations need to have an appropriate disciplinary policy, which is accessible to all and widely understood. A disciplinary policy should clearly indicate what behaviours are considered unacceptable and how the organization will respond in such cases. The disciplinary policy needs to be applied fairly and consistently.

Finally, if organizations and individuals who report safety issues are protected and treated in a consistent manner, are more likely to report their experiences and errors in an environment where they will not be judged or treated unfairly by their peers or their employer.

Overall, organizations and individuals must believe they will be supported when reporting in the interest of safety. This includes organizational and personal errors and mistakes. An increase in confidential reports and a decrease in anonymous reports is usually indication of the organization's progress towards a positive safety culture.

8.3.2. Safety Reporting

8.3.2.1. Significance of Safety Reporting

Writing a report after having been involved in an incident often seems to be and feels like an inconvenient, time-consuming, and worthless action. However, it is way more than that – and important and helpful in diverse ways.

- Safety

Reporting enables the organization and the personnel to understand what happened, to learn from past events and to make things safer in future. This means, it is about procedures, rules and standardisation and the potential difference between 'work as done' and 'work as imagined' (which is shaped by 'work as prescribed' in rules and procedures).

- Law

Reporting is compliant with applicable law and hence enables the organization to support its individuals. By law, any incident with a safety-relevant aspect must be reported. In other words, failing to report will lead to the breach of the law and a committed offence. It will not be regarded as a mistake and, in case of detection, the concerned will be prosecuted regardless of the actual event/ incident, as it is a breach of criminal law – and will be treating as such.

- Double bind situation

All the states and service providers are highly interested in a continuously improved and safer working environment, which is why they fully supports the established reporting processes and expect to keep on reporting any safety-relevant event. Furthermore, no one wants to be confronted with any legal issues based on non-compliance with law.

On the other hand, it is obvious that reporting may raise questions about accountability and possible legal proceedings, but none of these issues may be solved by non-reporting.

There is no way out of this so called “double bind” situation, where opposing interests of safety and judiciary must be served and satisfied.

Overall safety reporting is;

- **not about convenience.** Reporting is not only important for safety but also a legal requirement and therefore should be compliant with applicable law. Reporting shall be a normal routine after having been involved in an incident.
- **not about time.** Reporting is about your very own, your colleagues’ and your organization’s safety and reputation.
- **not worthless.** Reporting enables the whole ATM system to get safer.
- **about content.** Reporting can be done in many ways, from a noticeably short, factual, and static report to a very descriptive and safety-wise helpful, but not a self-incriminating report of the occurrence.

8.3.2.2. Dos and don’ts

This is a crucial point. It should be emphasized, while writing safety reports that

- the language used in filing a report shall be neutral,
- no names shall be stated (neither first/last names nor initials),
- the information provided shall be kept short and factual to protect yourself, especially from unintentional and unconscious self-incrimination,
- the information provided shall be fact-bound, non-emotional and refrain from finger pointing,
- judgments, assumptions and/or interpretations shall not be part of a report,
- wording such as e.g. – “I forgot...” – “I assumed...” – “I was not aware...” – “I was sure the equipment...” – “I thought it might...” –etc. shall be avoided.
- from a safety point of view, it is best to provide as much information as possible but from a legal point of view, it is best to keep the information as short and factual as possible.

8.3.3. Just Culture

8.3.3.1. Definition

A Culture where front-line operators or other personnel are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated. Just culture policies that distinguish wilful acts of misconduct from inadvertent errors, providing for an appropriate punitive or non-punitive response (a disciplinary policy), are essential to ensure the effective reporting of systemic safety deficiencies. [European Commission, Eurocontrol & IFATCA].

8.3.3.2. Just Culture conception

Just Culture is about safety. It is a question of mind-set, about fostering a constructive environment by which individuals can share their accounts to add to our knowledge of how the CNS/ATM system works. In doing so, just culture is a mechanism that allows to uncover pertinent aspects of the operation that are traditionally hidden.

The concept of Just culture represents the fundamental recognition that both aviation safety and the administration of justice would benefit from a carefully established equilibrium, moving away from fears of criminalisation, balancing, and satisfying the interests of two unique and not compatible worlds: The world of safety and the world of justice.

8.3.3.3. Just Culture misconception

Nothing quick or unambiguous

Just Culture is not about quick fixes, clear rules, strict guidelines, or a set of given norms. It is about a constant interaction

- between Safety and Judiciary to satisfy both needs,
- with internal, organisational justice processes.

No absolution, no “no blame culture”

Just culture does not mean complete protection of front-line ATSEP in the event of aviation incidents and accidents. Particularly, it does not offer protection in case of gross negligence, wilful misconduct and/or destructive acts, severe and serious disregard of an obvious risk and/or profound failure of professional responsibility. E.g.: Just Culture covers a reported incident – but not the omission of reporting!

No valid term in the legal world

FOCA, STSB, the Swiss Legislator and the EU have all acknowledged the importance of Just Culture, even though implementation of its principles is still lagging, especially in the criminal law. As Judiciary is bound to the law – with little to no scope to deviate from it for the benefit of Just Culture and/or the accused – it is subject to a case-by-case appreciation by the competent judicial authority.

8.3.4. Safety Culture and Cultural Diversity

From a safety management perspective, national culture influences organizational culture and plays a large part in determining the nature and scope of regulatory enforcement policies, including the relationship between regulatory authority personnel and industry personnel, and

the extent to which safety information is protected. These, in turn, impact on peoples' willingness to report safety issues.

When implementing safety management, managers should be capable of moulding their culturally diverse workforce into effective teams. Eliminating differences in safety risk perceptions that may derive from diverse cultural interpretations and enhancing other safety-related aspects, such as communication, leadership styles and interaction between supervisors and subordinates is key. The degree of success will depend on management's ability to promote a mutual understanding of safety and everyone's role in its effectiveness. Regardless of an individual's cultural background, effective safety management relies on a shared safety culture, with everyone in the organization understanding how they are expected to behave in relation to safety and risk "even when no one is watching."

8.4. Challenges and Addressing the Roadblocks

8.4.1. Loss of Upper Management Support

- Without having the top management support, we can never think of an aviation SMS. Loss of top or upper management support can be attributed to:
 - Change in top-level leadership.
 - Changing attitudes toward the Aviation SMS due to other prevailing strategic opportunities/challenges; or
 - Safety management team not performing their jobs regarding regular communications with upper management.
- To regain top/upper management support, the safety manager (accountable for safety) will need to start at the very top and open a dialog with the accountable executive. Topics to enforce include:
 - Requirements of the aviation safety work culture and SMS.
 - Benefits of the aviation safety work culture and SMS.
 - Importance of top/upper management support.
 - Methods to demonstrate top-level support of the aviation safety program.

8.4.2. Lack of Safety Accountability

The second most significant reason for aviation safety work culture implementation failure is the loss of the sole safety manager. Safety managers are the key personnel and if the corporate knowledge leaves the organisation, the safety program will collapse.

- Strategies to minimize this risk include:
 - Having another "part-time" safety manager who understands how the safety program functions.
 - Requiring 30-days prior notice before key personnel leave the organisation to be "eligible" for rearrangement.
 - Training department should head in safety program activities.
- An excellent alternative to role of safety manager is to actively involve department heads in the workings of the SMS. There will be additional benefits, including:
 - Increased involvement and buy-in to the safety program.
 - Improved responsiveness toward risk management activities.

8.4.3. Lack of leadership commitment

A positive safety culture relies on a high degree of trust and respect between personnel and management. Time and effort are needed to build a positive safety culture, which can be easily damaged by management decisions and actions, or inactions. Continuous effort and reinforcement are needed.

Visible demonstrations of leadership support towards safety program are paramount to the success of service provider's safety program. Common displays commitment of top-level support include:

- Newsletter articles from the accountable executive detailing the importance of the Safety.
- Offering regular (weekly or bi-weekly) meetings with the safety manager; and
- Occasionally walking through the area of operations with the safety manager to demonstrate that the safety team has upper management's support.

8.4.4. Lack of resources for safety success

The situations where there is a lack of

- improved tool and workplace architecture to match the fast pace of change of technological development.
- or adequate safety training and well equipped ATSEP,

may lead to inability of the ATSEP to fulfil the safety objectives as set by the ANSPs.

Safety Training /Education programs to improve the knowledge and skill of ATSEP to handle the safety challenges should be included in SMS/SSP and necessary resources and guidance should be provided to ATSEP to adapt to changing work environment. Also, the provision of environmental and equipment safety skills to ATSEP regarding equipment and material storage and disposal or maintaining general office hygiene or handling equipment with high radiation.

8.4.5. Ageing workforce

ATSEP with more years of services may sometimes feel reluctant to adapt to changing work environment and fast pace of technological developments and in turn may not follow the safety work culture demands. Aged and senior executives may also avoid knowledge sharing to lower subordinates due to some superiority complex.

Sensitizing the ageing workforce about safety aspects and knowledge sharing with lower subordinates to improve the positive safety culture among all levels of workforce is important.

8.4.6. Rise in the recruitment of young and less experienced ATSEP

It is no secret that newly joined ATSEP by far may pose the greatest risk to safety in the aviation industry and beyond if not guided properly. as they are:

- unfamiliar with the work environment.
- impressionable to existing norms in the work environment; and
- unfamiliar with existing policies/procedures.

This considerable amount of risk involved with new ATSEP can be mitigated by a strong safety culture which:

- requires teamwork that acts as a natural monitor and guide for new ATSEP.
- exhibits truly little negative norms that could potentially lead a new ATSEP into dangerous action.
- always has a strong precedent of safety training (induction and recurring); and
- will surely has strong leaders to keep new ATSEP “on track” in terms of behaving safely.

8.4.7. Loss of safety-related data

Safety-related data like databases, spreadsheets, safety reporting documents are critical to the organisation. During any Safety breaches like Cyber security attacks, leakage of such critical information may pose serious threat to the aviation industry.

Mitigation strategies for loss of safety-related data include:

- Utilizing in-house centralized databases and file systems.
- Using cloud-based, professionally designed aviation safety management system solutions; and
- Enforce regular backup strategies for all safety-related data.
- Imparting Cyber security.

8.4.8. Safety Feedback problems

This problem may arise due to-

- Not collecting feedback
- Doing nothing with collected feedback

Proper way of collecting safety data and safety feedback builds up trust between the ATSEP and the management ensuring positive safety and just culture in the organisation.

8.4.9. Safety culture and organizational change

Safety management requires that organizations manage the safety risks associated with organizational and operational changes. Staff concerns about workload, job security and access to training are associated with meaningful change in organizations and can have a negative impact on safety culture. The degree to which staff feel involved in the development of change and understand their role in the process will also influence the safety culture.

8.4.10. Economic unpredictability

This situation may arise due to any unprecedented situation like COVID-19. This can be addressed if SMS/SSP includes preparedness during emergency situations.

8.5. Monitoring and Measuring Safety Culture Effectiveness

8.5.1. Safety Culture Assessment

Safety culture is subject to many influences and organizations may choose to assess their safety culture to:

- understand how people feel about the organization and how importantly safety is perceived.
- identify strengths and weaknesses.
- identify differences between various groups (subcultures) within an organization; and
- examine changes over time (e.g., in response to significant organizational changes such as following an accident, a change in senior management or altered industrial relations arrangement).

There are several ways which can be used to assess safety culture maturity, usually in combination of:

- questionnaires.
- interviews and focus groups.
- observations; and
- document reviews.

Measuring of the effectiveness of safety work culture can be done by:

- reviewing the programs and procedures in place for upgradation to suit the requirement.
- establishing communication between management and ATSEP for active culture assessment to be handled with care and empathy.

- assessing the safety training which gives the clue about the organisation's commitment to safety.

Assessing safety culture maturity can provide valuable insight, leading to actions by management that will encourage the desired safety behaviours. It should be noted that there is a degree of subjectivity with such assessments, and they may reflect the views and perceptions of the people involved at a particular moment only. Also, scoring safety culture maturity can have unintended consequences by inadvertently encouraging the organization to strive to achieve the “right” score, rather than working together to understand and improve the safety culture.

8.6. References

- ICAO-ANNEX 19 Safety Management
- DOC-9859 Safety Management Manual Fourth Edition 2018
- APAC Seamless ANS Plan (V3.0) Safety Culture Survey
- EURO CONTROL ATM Safety Framework Maturity Survey Methodology for ANSPs ESP-2009-78
- CANSO Standard of Excellence in Safety Management System.
- SWISS ATCA Just Culture Manual for ATCO, ANSE & ATSEP Behaviour after an incident and further proceedings

APPENDIX-9: SELF EVALUATION CHECK LISTS

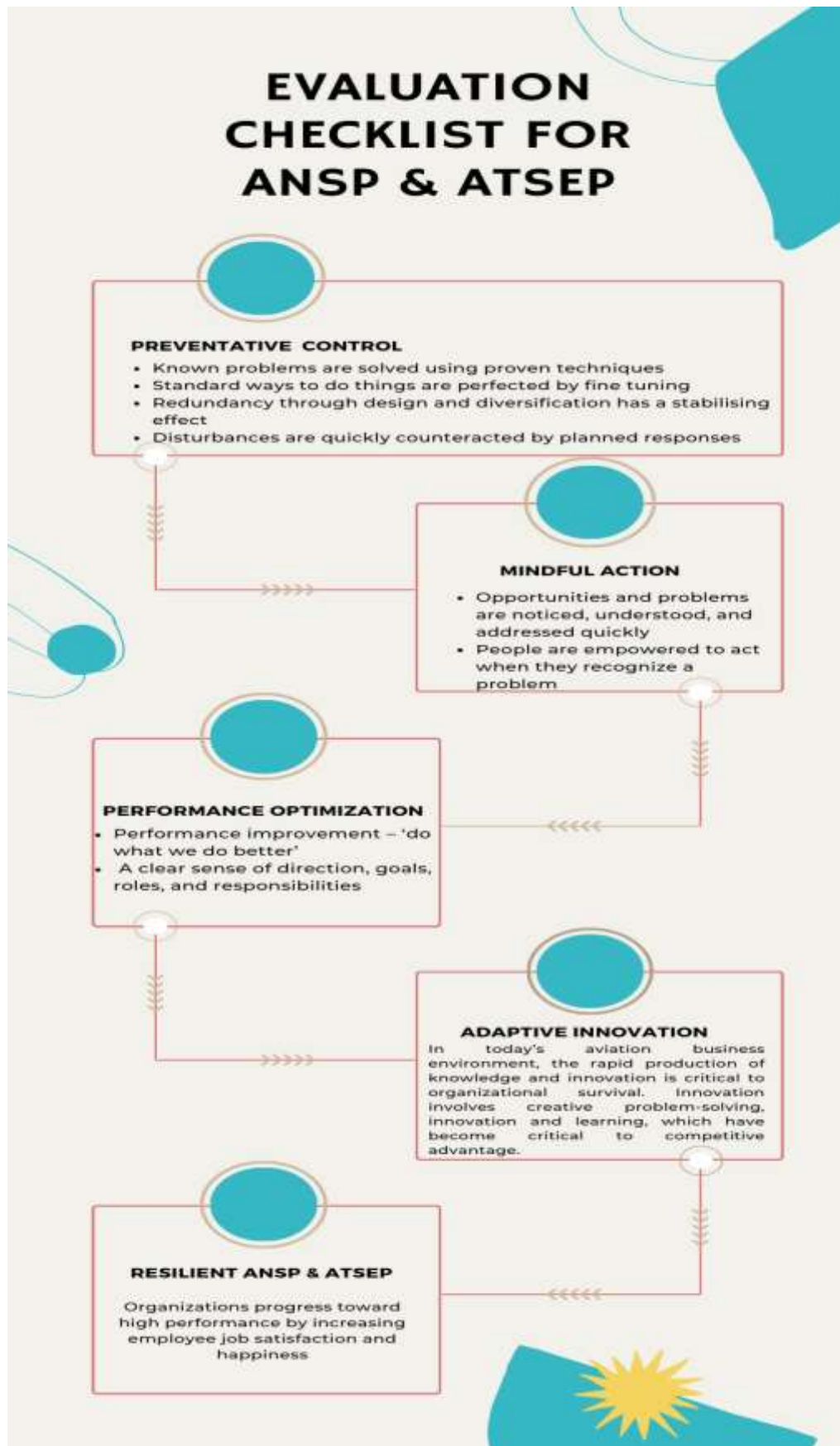


Figure 16: Understanding the evaluation check list process.

Self-Evaluation Check list for ANSP**Human performance management processes maturity level
Self-Evaluation Check list for ANSP – PEOPLE RESOURCING**

##	Process	Maturity level	Description of the maturity level	Tick
1)	Strategic people resourcing for directly addressing the factors that are adding stress and fatigue to ATSEP due to over workload and due to lack of human resources	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria	
2)	Strategic people resourcing for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to over workload and due to lack of human resources	Level A		
		Level B		
		Level C		
		Level D		
		Level E		
3)	Strategic people resourcing for addressing the factors that are aggravating stress and fatigue when the workload is more, and human resources are less	Level A		
		Level B		
		Level C		
		Level D		
		Level E		
4)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation		
5)	If maturity level is D w.r.t score of (1)			
	Do you have workforce planning based on projected changes?			Y/N
	Did you recruit people as per the workforce planning?			Y/N
	Did you provide better opportunities and better working conditions to your people?			Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>			

ATSEP HUMAN FACTORS GUIDANCE MATERIAL

6)	If maturity level is E w.r.t score of (1)	
	Did you revise the workforce planning in the last two years?	Y/N
	Did you revise the recruitment process to suit the safety and service strategy?	Y/N
	Are you able to get more competitive people successively from the market?	Y/N
	Have you set the key performing indicators for measuring the above?	Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>	
	<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>	

Human performance management processes maturity level				
Self-Evaluation Check list for ANSP – <u>JOB, ROLE AND SKILLS ANALYSIS AND</u>				
<u>COMPETENCY MODELLING</u>				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Job, role and skills analysis and competency modelling for directly addressing the factors that are adding stress and fatigue to ATSEP due to ambiguities on accountabilities and responsibilities.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria	
2)	Job, role and skills analysis and competency modelling for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to ambiguities on accountabilities and responsibilities.		Level A	
			Level B	
			Level C	
			Level D	
			Level E	
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation		
4)	If maturity level is D w.r.t score of (1)			
	Do you have clear job description?			Y/N
	Did you have clear role profile?			Y/N
	Do you have competency modelling of both behavioural and functional competencies?			Y/N
	Do you have annual training plan prepared based on the role profiles of ATSEP?			Y/N

ATSEP HUMAN FACTORS GUIDANCE MATERIAL

	<i>If your score is one or more "N," please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>	
5)	If maturity level is E w.r.t score of (1)	
	Have you done the job evaluation of your ATSEP job role profiles in the last two years?	Y/N
	Have you recruited new ATSEP based on the outcome of this process?	Y/N
	Is ATSEP performance management system designed as per the outcome of this process?	Y/N
	Have you set the key performing indicators for measuring the above?	Y/N
	<i>If your score is one or more "N," please assume the immediate lower level of maturity and evaluate</i>	
	<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>	

Human performance management processes maturity level Self-Evaluation Check list for ANSP – <u>KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT</u>				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Knowledge management, talent management, learning and development for directly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria	
2)	Knowledge management, talent management, learning and development for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A		
		Level B		
		Level C		
		Level D		
		Level E		
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation		

ATSEP HUMAN FACTORS GUIDANCE MATERIAL

4)	If maturity level is D w.r.t score of (1)	
	Have you established organizational knowledge management?	Y/N
	Have you managed talent management to match with the strategic people resourcing?	Y/N
	Have you established learning and development system for individuals as well as teams?	Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>	
5)	If maturity level is E w.r.t score of (1)	
	Did you bring new knowledges in the knowledge management in the last year?	Y/N
	Did you bring any changes in the talent planning to suit the safety and service strategy in last two years?	Y/N
	Did you evaluate the effectiveness of the learning and development process in last year?	Y/N
	Have you set the key performing indicators for measuring the above?	Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>	
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>		

Human performance management processes maturity level Self-Evaluation Check list for ANSP – <u>INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY</u>				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Induction of new systems and maintenance philosophy for directly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria	
2)	Induction of new systems and maintenance philosophy for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.		Level A	
			Level B	
			Level C	
			Level D	
			Level E	
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation		

ATSEP HUMAN FACTORS GUIDANCE MATERIAL

4)	If maturity level is D w.r.t score of (1)	
	Maintenance strategy includes all the process in addition to preventive maintenance	Y/N
	All the maintenance activities are documented for easy traceability	Y/N
	Annual reactive maintenance duration is only 20% or less than the total maintenance duration?	Y/N
	Required competencies and resources made available prior to the installation of new systems.	Y/N
	All OEM documents required to meet the maintenance strategies were ensured before SAT	Y/N
	Computer-based maintenance data analysis established for financial optimization	Y/N
	Root cause analysis is being practiced on safety sensitive facilities for finding primary failures	Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>	
5)	If maturity level is E w.r.t score of (1)	
	Innovated means of observations and data logging done for automated investigation	Y/N
	Continuous improvement on maintenance process including training done as per new systems	Y/N
	Annual reactive maintenance cost is reduced when compared to last year	Y/N
	Computer based maintenance data analysis helped in carrying out predictive maintenance	Y/N
	Repeated failures were analysed through root cause failure and identified primary failures	Y/N
	Trained and developed ATSEP on FAT, SAT, and document verification to ensure OEM documents and system delivered as per the user requirements.	Y/N
	Have you set the key performing indicators for measuring the above?	Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>	
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>		

Human performance management processes maturity level Self-Evaluation Check list for ANSP – <u>WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD</u>				
##	Process	Maturity level	Description of the maturity level	Tick
1)	Work environment, well-being, performance, and reward for directly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	Human performance management processes and/or requirements have not been agreed at the organization level – they are either not routinely undertaken or depend on the individual assigned the task	
		Level B	Human performance management processes and/or requirements are defined but not yet fully implemented, documented, or consistently applied.	
		Level C	Human performance management processes and/or requirements meet the required regulatory standards and comply with relevant ICAO Annexes. Human performance management processes and/or requirements are formally documented and consistently applied	
		Level D	Evidence is available to provide confidence that human performance management processes and/or requirements are being applied appropriately and are delivering positive, measured results.	
		Level E	Human performance management processes and/or requirements set international best practice, focusing on innovation and improvement. The effectiveness of the human performance management improvement actions is measured and evaluated against defined improvement criteria.	

ATSEP HUMAN FACTORS GUIDANCE MATERIAL

2)	Induction of new systems and maintenance philosophy for indirectly addressing the factors that are adding stress and fatigue to ATSEP due to improper tools, procedures and shared knowledge and practices.	Level A	
		Level B	
		Level C	
		Level D	
		Level E	
3)	Resilience Level w.r.t score of (1)	A & B – Preventative Control, C- Mindful action, D-Performance optimization, E – Adaptive innovation	
4)	If maturity level is D w.r.t score of (1)		
	Total reward system approaches in practice that emphasize the enhanced work environment.		Y/N
	Work environment is conducive to high performance.		Y/N
	Performance management system in practice ensures the support and guidance people need to develop and improve are readily available.		Y/N
	Reward system includes non-financial rewards like recognition, achievement, personal growth		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and take necessary measures to reach the next level.</i>		
5)	If maturity level is E w.r.t score of (1)		
	Work environment is periodically reviewed for enhancement		Y/N
	Increased level of job satisfaction and happiness found after enhancing work environment		Y/N
	Unique values added by all the employees were recognized and rewarded		Y/N
	Increased level of engagement among the workforces were observed		Y/N
	Have you set the key performing indicators for measuring the above?		Y/N
	<i>If your score is one or more “N,” please assume the immediate lower level of maturity and evaluate</i>		
<i>If your final level of maturity is D or E, please ascertain with the self-evaluation of ATSEP</i>			

Self-Evaluation Check list for ATSEP

Human performance management processes maturity level Self-Evaluation Check list for ATSEP – <u>PEOPLE RESOURCING</u>					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood the strategic requirements of my ANSP?			Y/N
	B	I have psychological contract with ANSP, that has built the mutual trust, increased commitment, and engagement.			Y/N
	C	I have improvised my unique talent and skills and adding values to my ANSP			Y/N
2)	<i>If your choice for one or more questions is "N," please state the specific reasons</i>				
	A				
	B				
	C				

Human performance management processes maturity level Self-Evaluation Check list for ATSEP – <u>JOB, ROLE AND SKILLS ANALYSIS AND COMPETENCY MODELLING</u>					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood the key result areas and accountabilities of my role			Y/N
	B	I have understood the knowledge, skill, and competency requirements for my role			Y/N
	C	I have developed the knowledge and skills needed to achieve an acceptable level of performance			Y/N
2)	<i>If your choice for one or more questions is "N," please state the specific reasons</i>				
	A				
	B				
	C				

Human performance management processes maturity level
Self-Evaluation Check list for ATSEP – KNOWLEDGE MANAGEMENT, TALENT MANAGEMENT, LEARNING AND DEVELOPMENT

##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood the opportunities for my career development and growth.			Y/N
	B	I know the provisions for developing myself to core technical or professional roles			Y/N
	C	I have developed the leadership and management skills toward the career progression			Y/N
2)	If your choice for one or more questions is “N,” please state the specific reasons				
	A				
	B				
	C				

Human performance management processes maturity level
Self-Evaluation Check list for ATSEP – INDUCTION OF NEW SYSTEMS AND MAINTENANCE PHILOSOPHY

##		Process	Maturity level	Description of the maturity level	Tick
1)	A	I have understood all the process involved in the maintenance strategy of my ANSP			Y/N
	B	I have well documented all the activities of maintenance for easy traceability			Y/N
	C	I have acquired all the skills and competencies required for maintaining new systems			Y/N
	D	I have acquired the skills for carrying root cause failure analysis			Y/N
	E	I have made the annual plan for the spares and other materials including budgeting			Y/N
2)	If your choice for one or more questions is “N,” please state the specific reasons				
	A				
	B				
	C				

Human performance management processes maturity level Self-Evaluation Check list for ATSEP – <u>WORK ENVIRONMENT, WELL-BEING, PERFORMANCE, AND REWARD</u>					
##		Process	Maturity level	Description of the maturity level	Tick
1)	A	Work environment enabled me towards more engagement and commitment.			Y/N
	B	Work environment has reduced my stress and improved my work-life balance			Y/N
	C	I have not experienced or heard of any sexual harassment and bullying problems.			Y/N
	D	I am benefited by the individual as well as group services provide by my ANSP			Y/N
	E	I am highly motivated due to the non-financial reward systems in place.			Y/N
2)	If your choice for one or more questions is "N," please state the specific reasons				
	A				
	B				
	C				
	D				

COMPENDIUM

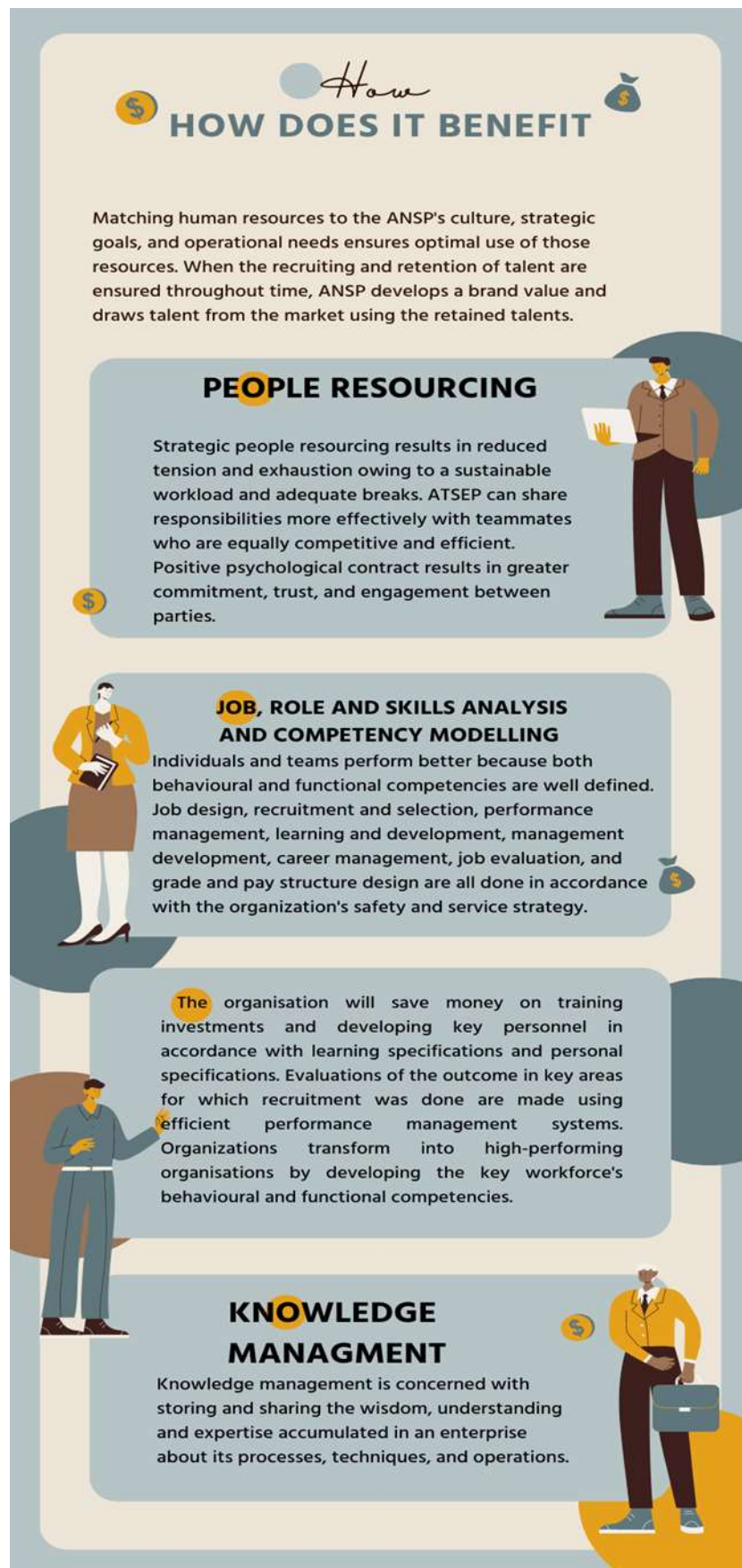


Figure 17: Compendium Picture 1

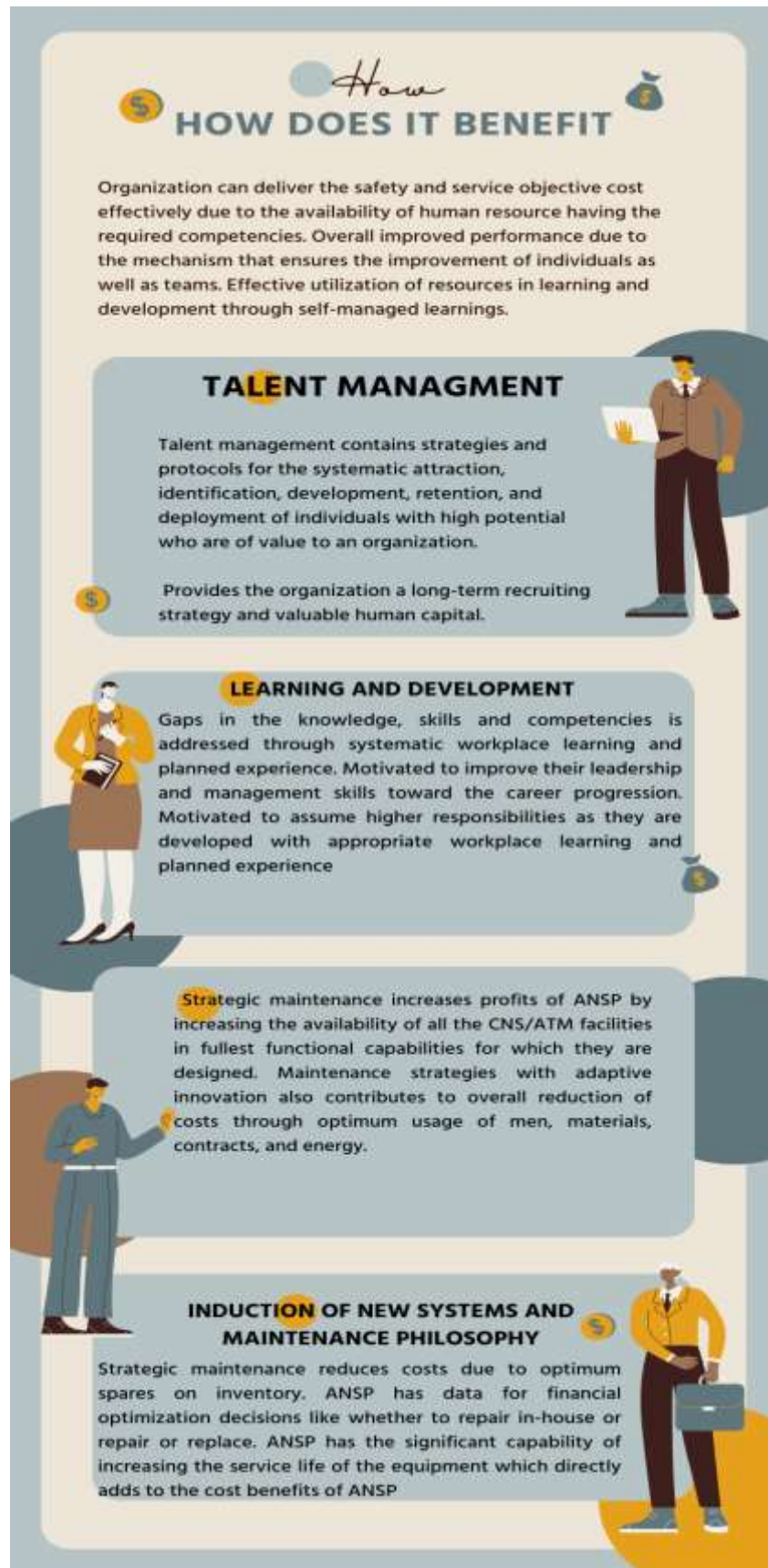


Figure 18: Compendium Picture 2

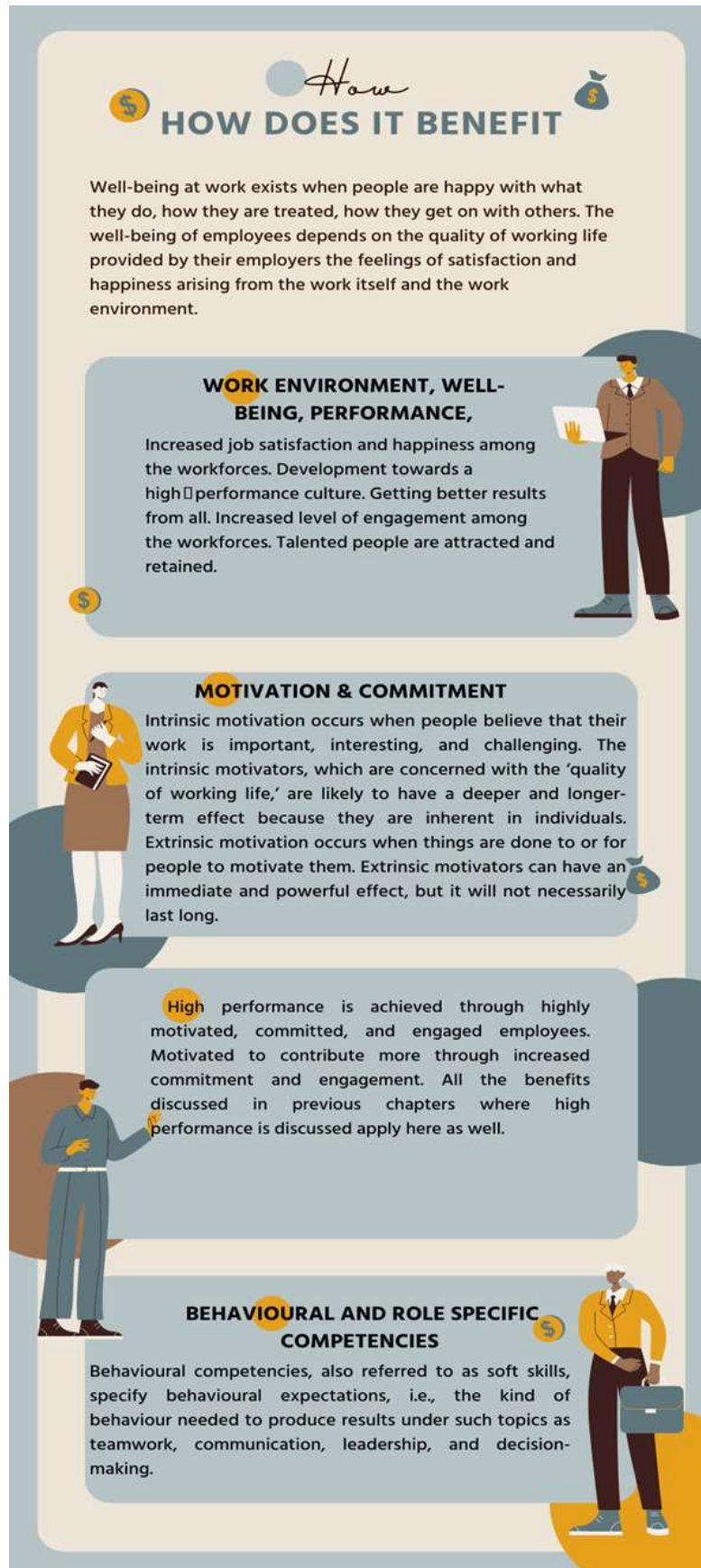


Figure 19: Compendium Picture 3



Figure 20: Compendium Picture 4

CNS SG/27
Appendix N to the Report

CNS POINTS OF CONTACT

(Key: **ADM** – Administration; **URG** –Urgent Matters)

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
	AFGHANISTAN		
ADM / URG	Eng. Mohammad Shaker Popal	CNS Acting Director Afghanistan Civil Aviation Authority	Tel: +93(0)799601095 (Mobile) Fax: - E-mail: engpopal@gmail.com * Suggested to include Mr. Toryalai Himat, Head of AIS and training, httoryal@gmail.com in emails with Afghanistan POC
	AUSTRALIA		
ADM	Airservices Australia – International Engagement team	Airservices Australia	Tel: - Fax: - E-mail: International@AirservicesAustralia.com
URG	Airservices Australia – Service Desk Airways (H24)	Airservices Australia	Tel: +61262685555 option 1 Fax: - E-mail: Cc TOCBNATM@AirservicesAustralia.com Cc TOCMLATM@AirservicesAustralia.com Cc International@AirservicesAustralia.com
	BANGLADESH		
ADM	Md. Mahabubur Rahman (2022.09.07) from CNS SG/26	Director (CNS) Civil Aviation Authority of Bangladesh	Tel: +88 02 41091032 Fax: +88 02 8901411 Mobile: +88 0189 490 8400 E-mail: dcnshq@caab.gov.bd

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Md. Mahabubur Rahman (2022.09.07) from CNS SG/26	Director (CNS) Civil Aviation Authority of Bangladesh	Tel: +88 02 41091032 Fax: +88 02 8901411 Mobile: +88 0189 490 8400 E-mail: dcnshq@caab.gov.bd Please copy Fax: +88 02 8901411 Mobile: +88 0189 490 0000 E-mail: chairman@caab.gov.bd
	BHUTAN		
ADM	<u>Karma Gayley</u>	<u>CNS officer/Bhutan civil Aviation Authority</u>	<u>kgayley@bcaa.gov.bt</u> ~~Tel:~~ ~~Fax:~~ ~~E-mail:~~
URG	<u>Devi Maya Adhikari</u>	<u>Dy. Exe. CNS Engineer /Department of Air Transport</u>	<u>dmadhikari@doat.gov.bt</u> ~~Tel:~~ ~~Fax:~~ ~~E-mail:~~
	BRUNEI DARUSSALAM		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	CAMBODIA		
ADM	Mr. Neang To (2022.09.08) from CNS SG/26	Chief of CNS Bureau State Secretariat of Civil Aviation Cambodia (SSCA)	Tel: +855 12820811 Fax: E-mail: Neangto.ans@gmail.com

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Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Mr. Heng Mengkong (2022.09.08) from CNS SG/26	Deputy Chief of CNS Bureau State Secretariat of Civil Aviation Cambodia (SSCA)	Tel: (+855) 16 398 599 Smart Fax: E-mail: hengmengkong@gmail.com
	CHINA		
ADM	Zhang De	Principal Staff/ Air Traffic Regulation Office, CAAC	Tel: +86 18610256306 Fax: +86 64092677 E-mail: zhangde@caac.gov.cn
URG	Wang Pengyu	Assistant/ Air Traffic Management Bureau, CAAC	Tel: +86 18511663906 Fax: +86 010-87786964 E-mail: wangpengyu.caac@foxmail.com
	HONG KONG, CHINA		
ADM	~~Derek HOWE~~ Lau Kin Hei, Arthur	~~Electronics Engineer~~ ~~Civil Aviation Department~~ ~~Electronics Engineer~~ ~~Civil Aviation Department~~	~~Tel: +852 2910 6586~~ ~~Fax: +852 2845 7160~~ ~~E-mail: cns_icao@cad.gov.hk~~ ~~Tel: +852 2910 6519~~ ~~Fax: +852 2845 7160~~ ~~E-mail: cns_icao@cad.gov.hk~~
URG	~~Hui Man Ho~~ Hui Man Ho	~~Assistant Director-General of Civil Aviation (Air~~ ~~Traffic Engineering Services)~~ ~~Civil Aviation Department~~ ~~Assistant Director-~~ ~~General of Civil Aviation (Acting)/~~ ~~Civil Aviation Department~~	~~Tel: +852 2910 6501~~ ~~Fax: +852 2845 7160~~ ~~E-mail: cns_icao@cad.gov.hk~~ ~~Tel: +852 2910 6501~~ ~~Fax: +852 2845 7160~~ ~~E-mail: cns_icao@cad.gov.hk~~
	MACAO, CHINA		

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Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	FIJI		
ADM	Sereima Bolanavatu	ANS Inspector (CNS) Civil Aviation Authority of Fiji (CAAF)	Tel: +679 999 5217 Fax: +679 672 1500 E-mail: sereima.bolanavatu@caaf.org.fj
URG	Sereima Bolanavatu	ANS Inspector (CNS) Civil Aviation Authority of Fiji (CAAF)	Tel: +679 999 5217 Fax: +679 672 1500 E-mail: sereima.bolanavatu@caaf.org.fj
	FRANCE		
	FRENCH POLYNESIA		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	NEW CALEDONIA		
ADM	Mr. Jérôme Patoureaux (2022.05.09)	Chief of Technical Division DSNA / France	Tel: Fax: E-mail: dac-nc-sna-chef-dt@aviation-civile.gouv.fr

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Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
	WALLIS AND FUTUNA ISLANDS		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	INDIA		
ADM	~~G. S. Rao~~ S K Mallik	ED (CNS-OM)/ Airports Authority of India	Tel: +91 (11) 2081 8210 Fax: +91 (11) 2465 4142 E-mail: edcnsom@AAIAERO
URG	~~G. S. Rao~~ S K Mallik	ED (CNS-OM)/ Airports Authority of India	Tel: +91 (11) 2081 8210 Fax: +91 (11) 2465 4142 E-mail: edcnsom@AAIAERO
	INDONESIA		
ADM	Budi Fathoni	Air Navigation Inspector of CNSA/ DGCA of Indonesia	Tel: +628563356444 Fax: E-mail: bfathoni@yahoo.com
ADM	Muhammad Ryan	Meteorological Information Dissemination Officer, BMKG/ Indonesian Meteorology, Climatology, and Geophysical Agency.	Tel: +6281343160168 Fax: E-mail: muhammad.ryan@bmkg.go.id
ADM	Subhan Bin Awad Syawie	Junior Manager of Communication Facility Readiness/ Airnav Indonesia	Tel: +6285240490004 Fax: E-mail: Subhan2902@gmail.com
URG	Arian Nurahman	Air Navigation Inspector of CNS/ DGCA of Indonesia	Tel: +6285695414428 Fax: E-mail: ariannurahman@gmail.com

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Ardhian Riansyah Cono	Meteorological Public Operation Management Officer, BMKG/ Indonesian Meteorology, Climatology, and Geophysical Agency	Tel: +6285215039595 Fax: E-mail: ardhian1595@gmail.com
URG	Dedy Iskandar	Junior Manager of Surveillance and Automation Facility Readiness/ Airnav Indonesia	Tel: +6285219917747 Fax: E-mail: dedy.nav7@gmail.com
	JAPAN		
ADM	Mr. Masahiro NAKAKUBO (2023.07.04)	Air Navigation Services Department JCAB	E-MAIL: nakakubo-m44ij@mlit.go.jp
	Mr. Toshiyuki DANZUKA (2023.07.04)	Air Navigation Services Department JCAB	E-MAIL: danzuka-t2p8@mlit.go.jp
URG	CNS Operations Coordination(24H) (2023.07.04)	Air Traffic Management Center(24H) JCAB	E-MAIL :cab-cnsunyou@mlit.go.jp TEL: +81-92-608-8888 (092-608-8888)
	KIRIBATI		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	LAO PDR		
ADM	Mr. Soudalath (2022.09.30)	CNS Officer, Air Navigation Standards Division Department of Civil Aviation, Lao	Tel: +856 (21) 513 163 Mobile: +856 (20) 55995009 Fax: +856 (21) 513 177 E-mail: S.khamsoy@gmail.com ;

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
ADM	Mr. Somphavanh KINGSADA (2022.09.30)	Deputy Director, Technical Division Lao Air Navigation Service	Tel: - Mobile: +856 (20) 55675292 Fax: - E-mail: somphavanhking@gmail.com ;
URG	Mr. Moukphamay THAMMVONGSA (2022.09.30)	CNS Officer, Air Navigation Standards Division Department of Civil Aviation, Lao	Tel: +856 (21) 513 163 Mobile: +856 (20) 9977 5994 Fax: +856 (21) 513 177 E-mail: moukth@msn.com ;
URG	Mr. Kongsavanh CHANTHAVONG (2022.09.30)	Officer, Technical Division Lao Air Navigation Service	Tel: - Mobile: +856 (20) 55817599 Fax: - E-mail: kongsavanh.lans@gmail.com ;
	MALAYSIA		
ADM/ URG	Mr. Azman bin Hitam (2022.09.19) from CNS SG/26	Senior Assistant Director Quality & Standards Division Civil Aviation Authority of Malaysia (CAAM)	Tel: +60388934175 E-mail: azman.hitam@caam.gov.my
URG	Mr. Sharudin Hashim (2022.09.19) from CNS SG/26	Principal Assistant Director (CNS) ANS Technical Division Civil Aviation Authority of Malaysia (CAAM)	Tel: +60385291208 E-mail: sharudin@caam.gov.my
URG	Mr. Shairyzal Bin Mohamad @ Azizan (2022.09.19) from CNS SG/26	Assistant Director ANS & Aerodrome Standard Division Civil Aviation Authority of Malaysia (CAAM)	Tel: +60388714387 Fax: +60388714135 E-mail: shairyzal.azizan@caam.gov.my
	MALDIVES		
ADM	<u>Ms. Fathimath Ahmed</u>	<u>Manager, Air Traffic Engineering</u>	<u>Mobile: +9609660646</u> ~~Tel:~~ ~~Fax:~~ ~~E-mail:~~
	<u>Mr. Ishag Abdulla</u>	<u>General Manager, Air Traffic Engineering</u>	<u>Mobile: +9607957235</u>

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	<u>Mr. Ibrahim Imran</u>	<u>Manager, Air Traffic Engineering</u>	<u>Mobile: +9607784344</u> ~~Tel:~~ ~~Fax:~~ ~~E-mail:~~
	<u>Mr. Ishag Abdulla</u>	<u>General Manager, Air Traffic Engineering</u>	<u>Mobile: +9607957235</u>
	MALSHALL ISLANDS		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	MICRONESIA (FEDERATED STATES OF)		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	MONGOLIA		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	MYANMAR		

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
ADM	MR. ZAW MIN OO	DEPUTY GENERAL MANAGER (CNS) DEPARTMENT OF CIVIL AVIATION MYANMAR	Tel: +951-7533020, +959-425324449 Fax: +9517-533016 Email: zawminoo76@gmail.com , zawminoo.cns@dcamyanmar.aero
URG	MR. AUNG MYO	ASSISTANT GENERAL MANAGER (CNS) DEPARTMENT OF CIVIL AVIATION MYANMAR	Tel: +951-7533052, +959-5414430 Fax: +9517-533016 Email: aungmyo.ms@gmail.com , aungmyo@dcamyanmar.aero
URG	MR. HTET ARKAR	EXECUTIVE ENGINEER (CNS) DEPARTMENT OF CIVIL AVIATION MYANMAR	Tel: +951-7533024, +959-5213154 Fax: +9517-533016 Email: kohtetarkar@gmail.com , htetarkar@dcamyanmar.aero
	NAURU		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	NEPAL		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	NEW ZEALAND		

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
ADM	Melaia Folaumoeloa	National Continuous Monitoring Coordinator /ICAO Liaison Civil Aviation Authority of New Zealand	Tel: +64 4 560 9400 Fax: E-mail: Policyand.InternationalRelationsUnit@caa.govt.nz
URG	Sean Rogers	Manager Aeronautical Services Civil Aviation Authority of New Zealand	Tel: +64 27 807 4875 Fax: E-mail: aeronautical.services@caa.govt.nz
URG	Mark Blanchard (back-up for No. 1 point of contact)	Head of Policy and Standards Airways New Zealand	Tel: +64 27 597 5604 Fax: E-mail: PolicyandStandards@airways.co.nz
	PAKISTAN		
ADM	Saeed Ahmed Butt CAA/OF3974	Director CNS Engineering Pakistan Civil Aviation Authority	Tel: +92 21 9907 2200 Fax: +92 21 9924 2121 E-Mail: Director.CNS@caapakistan.com.pk
URG	Engr. Muhammad Asad Khan Niazi CAA/OF3137	Joint Director Radar (Maint/ Plans) Pakistan Civil Aviation Authority	Tel: +92 21 99242194 Fax: +92 21 34604329 E-Mail: mak.niazi@caapakistan.com.pk
	PALAU		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:

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Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
	PAPUA NEW GUINEA		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	PHILIPPINES		
ADM	Elmer E. Gomez	Acting Department Manager III Air Navigation Service	Tel: +63 (2) 7944 2318 Fax: E-mail: anod@caap.gov.ph
URG	Gary M. Jadie	Acting Department Manager III Air Navigation Service	Tel: +63 (2) 7944 2205 Fax: E-mail: garymjadie@caap.gov.ph
	REPUBLIC OF KOREA		
ADM	Kyung-Joon Jang (2022.09.13) from CNS SG/26	Deputy Director Ministry of Land, Infrastructure and Transport (MOLIT)	Tel: +82 44-201-4350 Fax: +82 44-201-5637 E-mail: skyjan@korea.kr
ADM	Yu-Jin Kim (2022.09.13) from CNS SG/26	Assistant Director Ministry of Land, Infrastructure and Transport (MOLIT)	Tel: +82 44-201-4364 Fax: +82 44-201-5637 E-mail: kyjin22@korea.kr
URG	Kyung-Joon Jang (2022.09.13) from CNS SG/26	Deputy Director Ministry of Land, Infrastructure and Transport (MOLIT)	Tel: +82 44-201-4350 Fax: +82 44-201-5637 E-mail: skyjan@korea.kr

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Yu-Jin Kim (2022.09.13) from CNS SG/26	Assistant Director Ministry of Land, Infrastructure and Transport (MOLIT)	Tel: +82 44-201-4364 Fax: +82 44-201-5637 E-mail: kyjin22@korea.kr
	SINGAPORE		
ADM/URG	Lee Suk Leng (2022.09.15) from CNS SG26	Head (Radar & ADS-B) Civil Aviation Authority of Singapore	Tel: +65 6422 7070 Fax: - E-mail: Lee_Suk_Leng@caas.gov.sg
ADM/URG	Chew Keng Boon (2022.09.15) from CNS SG26	Head (Communications) Civil Aviation Authority of Singapore	Tel: +65 6422 7005 Fax: - E-mail: chew_keng_boon@caas.gov.sg
	SOLOMON ISLANDS		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	SRI LANKA		
ADM	Mrs. N.S.Casseer	Deputy Director General- Airspace Regulations Civil Aviation Authority Sri Lanka	Tel: +94112358821/+94112253496 Email: ddgasr@caa.lk
ADM	Mr. M.A.K.Prasanna	Director Air Navigation Services Civil Aviation Authority Sri Lanka	Tel: +94112358849/+94112253863 Email: dans@caa.lk
ADM	Eng. Jananath Konara Rathninda	Head of Electronics & Air Navigation Engineering, Airport & Aviation Services Sri Lanka (PVT) limited	Tel : +94773834032/+94112263600 Fax: +94112252400 Email: head.eane@airport.lk

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Eng. Mihiri Kumari	Senior Electronics Engineer Airport & Aviation Services Sri Lanka (PVT) limited	Tel : +94768242736, Fax: +94112633488, Email: mihiri.eane@airport.lk
URG	Eng. Asanga Bandara Senarath	Senior Electronics Engineer Airport & Aviation Services Sri Lanka (PVT) limited	Tel: +94768242654, Fax: +94112252400, Email: asanga.eane@airport.lk
URG	Eng. Vidura Thammitage	Senior Electronics Engineer Airport & Aviation Services Sri Lanka (PVT) limited	Tel : +94768242735, Fax: +94112633488, Email: vidura.eane@airport.lk
URG	Eng. Prasanna Wijeratna	Electronics Engineer Airport & Aviation Services Sri Lanka (PVT) limited	Tel : +94779975589, Fax: +94112633488, Email: prasannaw.eane@airport.lk
	THAILAND		
ADM	Mr. Sarawoot Rungruengwajiake	Acting Head of Communication, Navigation and Surveillance Standards Division Air Navigation Services Standards Department Civil Aviation Authority of Thailand (CAAT)	Tel: +66 (2)568 8800 ext. 2510 +66 (89) 066 1313 (mobile) Fax: +66 (2) 568 8847 E-mail: sarawoot.r@caat.or.th
ADM	Dr. Amornrat Jirattigalachote (2022.09.09) from CNS SG/26	Strategic Planning Manager (Engineering) Aeronautical Radio of Thailand Ltd. (AEROTHAI)	Tel: +66 (2) 287 8262 (Office) +66 (81) 887 2535 (Mobile) Fax: E-mail: amornrat.ji@aerothai.co.th
ADM	CDR. Pasgorn Pohom, RTN	Navigation Aids Section, Base Operations Division, Naval Air Station, Royal Thai Naval Air Division U-Tapao Airport Authority	Tel: 083 978 7459 Fax: E-mail: tom_pasgorn@gmail.com

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Lt. JG. Chalor Uthai, RTN	Navigation Aids Section, Base Operations Division, Naval Air Station, Royal Thai Naval Air Division U-Tapao Airport Authority	Tel: 089 989-6726 Fax: E-mail: lor_uthai@hotmail.com
URG	Mr. Wittaya Chunvattanananon (2022.09.09) from CNS SG/26	Senior Director Aeronautical Radio of Thailand Ltd. (AEROTHAI)	Tel: +66 (2) 285 9061 (Office) +66 (89) 039 7425 (Mobile) Fax: E-mail: chun@aerothai.co.th
	TIMOR LESTE		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	TONGA		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	TUVALU		
ADM			Tel: Fax: E-mail:

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Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG			Tel: Fax: E-mail:
	USA		
~~ADM~~ ADM	~~Mr Shayne Campbell~~ Mr Shayne Campbell	~~Senior Air Traffic Representative, Asia Pacific Federal Aviation Administration Air Traffic Organization, Mission Support (AJV- I2) American Embassy, Singapore Senior Air Traffic Representative, Asia Pacific Federal Aviation Administration Air Traffic Organization, System Operations American Embassy, Singapore~~	~~Tel: +65 6476 9413 Mobile: +65 8909-1136 E-mail: shayne.a.campbell@faa.gov Tel: +65 6476 9462 Fax: E-mail: shayne.a.campbell@faa.gov~~
~~URG~~ URG	~~Mr Shayne Campbell~~ Mr Shayne Campbell	~~Senior Air Traffic Representative, Asia Pacific Federal Aviation Administration Air Traffic Organization, Mission Support (AJV- I2) American Embassy, Singapore Senior Air Traffic Representative, Asia Pacific Federal Aviation Administration Air Traffic Organization, System Operations American Embassy, Singapore~~	~~Tel: +65 6476 9413 Mobile: +65 8909-1136 E-mail: shayne.a.campbell@faa.gov Tel: +65 6476 9462 Fax: E-mail: shayne.a.campbell@faa.gov~~
	VALUATU		
ADM			Tel: Fax: E-mail:

CNS SG/27
Appendix N to the Report

CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG			Tel: Fax: E-mail:
	VIET NAM		
~~ADM~~	<u>Mr. Nguyen The Hung</u>	<u>Director/Air Navigation Department, CAAV</u>	<u>Tel: 84 24 38723600</u> <u>Email: hungand@caa.gov.vn</u> ~~Tel:~~ ~~Fax:~~ ~~E-mail:~~
~~URG~~	<u>Mr. Vu Ngoc Tuan</u>	<u>CNS Official/Air Navigation Department, CAAV</u>	<u>Tel: 84 24 38720199</u> <u>Email: vungoctuan@caa.gov.vn</u> ~~Tel:~~ ~~Fax:~~ ~~E-mail:~~
~~URG~~	<u>Mr. Ho Sy Tung</u>	<u>Deputy Director General/ Viet Nam Air Traffic Management Corporation</u>	<u>Tel: 84 913222564</u> <u>Email: tunghosy@vatm.vn</u>
	<u>Mr. Be Nhat Hoan</u>	<u>Director/CNS Department, Viet Nam Air Traffic Management Corporation</u>	<u>Tel: 84 913003737</u> <u>Email: benhathoan@caa.gov.vn</u>

ACTION ITEMS OF CNS SG/27					
Action Item	Subject	Status / Target Date	Action Party	Status	Remarks / follow-up
27-1	ACSICG will update the ATN Documentation Tree every year based on latest development of relevant ICAO documents mentioned in the ATN Documentation Tree	CNS SG/28	ICAO Secretariat, ACSICG	On-going	
27-2	All Member States were requested to update the Telecommunication infrastructure table on priority	30-Sep-23	All Member States	Open	
27-3	The Member States were requested to enhance network capabilities to support IWXXM requirements	CNS SG/28	All Member States	Open	
27-4	As Pakistan could not join the CNS SG/27 Meeting, the ICAO Secretariat will coordinate with Pakistan to get their intention to establish CRV connection with connected MID States. The ICAO Secretariat was requested to ascertain the intention of all members with entry/exit points between APAC and MID Regions	30-Sep-23	ICAO Secretariat	Open	
27-5	The ICAO Secretariat of APAC Office was requested to coordinate with the ICAO MID Office, send a letter mentioning the successful experience and benefits of CRV attained by APAC Member States after joining CRV, invite PCCW Global to present significant information about the CRV network and its benefits to MID ATS Messaging Management Centre Steering Group (MIDAMC STG) (equivalent to the ACSICG in APAC Region)	CNS SG/28	ICAO Secretariat	Open	
27-6	The ICAO Secretariat will coordinate with the MID office and PCCWG to organize a joint event to share the requested information with MIDAMC STG and other relevant ICAO MID Meetings	CNS SG/28	ICAO Secretariat	Open	
27-7	The selection and authorization of EMS within the region will be the next step after the EMS performance requirements are identified. Additionally, whether SWIM TF should select and authorize EMS within the region would need further deliberation in SWIM TF. ICAO Secretariat will share the request shared by the paper with SWIM TF.	CNS SG/28	ICAO Secretariat	Open	

ACTION ITEMS OF CNS SG/27					
Action Item	Subject	Status / Target Date	Action Party	Status	Remarks / follow-up
27-8	The Meeting noted that CRV OG is already deliberating on the way forward to efficiently utilize available CRV bandwidth to disseminate obligatory critical aeronautical messages. Further guidelines related to this aspect may be prepared by CRV OG for ACSICG consideration and adoption by CNS SG. The ICAO Secretariat will share the pertinent information mentioned in the paper with CRV OG for further action	CNS SG/28	ICAO Secretariat	Open	
27-9	ICAO HQ informed about the creation of a new inter panel task force to address the IPv6 addressing and other related mutual concerns, this may include the global guidelines for IPv6 dedicated address block for fixed service and A/G mobile service. ICAO Secretariat will further coordinate with appropriate ICAO HQ panels to update on the latest developments	CNS SG/28	ICAO Secretariat	Open	
27-10	A discussion for managing the IPv6 address space and DNS namespace could be initiated at the ACSICG and SWIM TF Meetings in the future	CNS SG/28	ACSICG, SWIM TF, ICAO Secretariat	Open	
27-11	Hong Kong China suggested the ICAO Secretariat to consolidate relevant experience from States/Administrations for High Resilience in Sustaining Operations of Critical Aeronautical Infrastructure into a guidance document for future reference	CNS SG/28	ICAO Secretariat, Hong Kong China	Open	
27-12	The Meeting also requested all Member States to nominate Point of Contact (PoC) to review CNS related updates that will be proposed by Ad-hoc Group and share PoC information with ICAO Secretariat by email at yluo@icao.int or snibhani@icao.int	CNS SG/28	ICAO Secretariat, All Member States	Open	
27-13	Hong Kong China suggested and IFATSEA agreed to update the guidance document's contents continuously. For example, it is worth considering incorporating the increasingly popular model to include the roles of supervisory and managerial roles of engineers who work with service providers and ensure their performance within the scope of activities as defined in DOC 10057	CNS SG/28	ICAO Secretariat, IFATSEA, Human factor guidance Ad-hoc Group	Open	
27-14	Human factors guidance material will be promoted in the other regions and in ICAO Assembly in the coming days	CNS SG/28	IFATSEA	Open	

CNS SG/27
Attachment 1 to the Report

List of Participants

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
1.	AUSTRALIA (1)			
	1.	Mr. Brad Parker	Manager CNS/ATM Civil Aviation Safety Authority	brad.parker@casa.gov.au;
2.	BHUTAN (2)			
	2.	Mr. Karma Gayley	CNS Officer, Bhutan Civil Aviation Authority	kgayley@bcaa.gov.bt;
	3.	Mr. Sonam Dorji	Communication/Navigation Engineer, Department of Air Transport	sonamdorji@doat.gov.bt;
3.	BRUNEI DARUSSALAM (2)			
	4.	Mr. Haji Azrol bin Haji Saruji	Chief Aeronautical Telecommunication Officer, Department of Civil Aviation Brunei Darussalam	Azrol.saruji@dca.gov.bn;
	5.	Mr. Muhammad Ruzaini bin Haji Rosli	Aeronautical Telecommunication Engineer, Department of Civil Aviation, Ministry of Transport and Infocommunications	Ruzani.hjrosli@dca.gov.bn;
4.	CHINA (9)			
	6.	Mr. ZHANG De	Principal Staff, China/ Air Traffic Regulation Office, CAAC	zhangde@caac.gov.cn;
	7.	Mr. ZHU Yanbo	Deputy General Manager, China/ Aviation Data Communication Corporation	zyb@adcc.com.cn ;
	8.	Mr. LI Xiaoyi	Director of CNS Division, China/ Southwest Regional Air Traffic Management Bureau, CAAC	3775591@qq.com;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	9.	Ms. ZHAO Jingjing	Senior Engineer, China/ Beihang University	jingjingzhao@buaa.edu.cn;
	10.	Mr. GUO Kai	Senior Engineer, China/ Beihang University	guokai@buaa.edu.cn;
	11.	Ms. CAI Jing*	Deputy Director of CNS Division, China/ Air Traffic Management Bureau, CAAC	caijing@atmb.net.cn;
	12.	Mr. LI Guang*	Senior Engineer, China/ Technical Center of Air Traffic Management Bureau, CAAC	liguang@atmb.net.cn;
	13.	Ms. LIU Rui*	Senior Engineer, China/ Aviation Data Communication Corporation	liurui@adcc.com.cn;
	14.	Mr. CUI Kaitao*	Senior Engineer, China/ The Second Research Institute of CAAC	cuikaitao@caacsri.com;
5.	HONG KONG, CHINA (6)			
	15.	Mr. Richard WU	Deputy Director-General of Civil Aviation	rckwu@cad.gov.hk;
	16.	Mr. MH HUI	Assistant Director-General of Civil Aviation	mhhui@cad.gov.hk;
	17.	Mr. Sze Lung How	Electronics Engineer, Civil Aviation Department of Hong Kong, China	dslhow@cad.gov.hk;
	18.	Ms. Olivia Sm Chan	Senior Operations Officer (Technical), Hong Kong Civil Aviation Department	osmchan@cad.gov.hk;
	19.	Ms. Yumi Tung	Electronics Engineer, Civil Aviation Department Hong Kong	yymtung@cad.gov.hk;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	20.	Mr. Patrick LAM	Senior Aeronautical Communications Supervisor, Civil Aviation Department Hong Kong	hhlam@cad.gov.hk;
6.	MACAO, CHINA (2)			
	21.	Mr. Keng Chong Sun	Head of IT And CNS Division, Cam - Macau International Airport Co. Ltd.	sonnysun@macau-airport.com;
	22.	Mr. Veng Tong Lo	Senior Safety Officer (CNS), Civil Aviation Authority of Macao SAR	freemanlo@aacm.gov.mo;
7.	FRANCE (1)			
	23.	Mr. Jérôme Patoureaux	Chief of Technical Division (ANSP) Direction Générale de l'Aviation Civile (DGAC)	jerome.patoureaux@aviation-civile.gouv.fr
8.	INDIA (5)			
	24.	Mr. Aniruddha Kumar Sharma	GM, CNS, CHQ, Airports Authority of India	Aniruddha@aai.aero;
	25.	Mr. A Saravanakumar	GM, CNS, CHQ, Airports Authority of India	gmcnssuru@aai.aero;
	26.	Mr. Ram Kishan	JGM, CNS, Delhi Palam, Airports Authority of India	Ram_Kishan@aai.aero;
	27.	Mr. Karan Singh Bhardwaj	AGM, CNS, RCDU, Airports Authority of India	KBhardwaj@aai.aero;
	28.	Mr. Mahesh Singh	SM, CNS, RCDU, Airports Authority of India	MaheshSingh@aai.aero;
9.	INDONESIA (7)			
	29.	Mr. Dedy Iskandar	Surveillance and ATM Facility Readiness - Head Office, AirNav Indonesia	dedy.nav7@gmail.com;

Note: * - Virtual Participant

ATTM. 1 - 3

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	30.	Mr. Lanang Wibisono	Planning of System and Service Facility Requirements, AirNav Indonesia	lanang.wibisono@gmail.com;
	31.	Mr. Rachmat Hidayat	Facility Readiness-Head Office, AirNav Indonesia	rachmathidayat2704@gmail.com;
	32.	Mr. Maruli Tua Edison Saragih	Air Navigation Inspector, DGCA INDONESIA	edisonsaragih@yahoo.com;
	33.	Mr. Taruna Jaya	Deputy Director of Air Navigation Engineering, DGCA Indonesia, Directorate of Air Navigation	taruna_jaya@yahoo.com;
	34.	Mr. Arian Nurahman	Air Navigation Inspector, Ministry of Transportation of Indonesia	arian.nurahman@gmail.com;
	35.	Mr. Arif Wiraputra	Jr.Manager of Lower Airspace Development, Perum LPPNPI (AirNav Indonesia)	wiraputraarif@yahoo.co.id;
10.	JAPAN (3)			
	36.	Mr. Masahiro Nakakubo	Special Assistant to The Director, Japan Civil Aviation Bureau	nakakubo-m44ij@mlit.go.jp;
	37.	Mr. Kenji Uehara	Chief Official, CNS Planning Office, Japan Civil Aviation Bureau (JCAB)	uehara-k46qj@mlit.go.jp;
	38.	Mr. Susumu Saito	Principal Researcher, National Institute of Maritime, Port, and Aviation Technology	susaito@enri.go.jp;
11.	LAO PEOPLE'S DEMOCRATIC REPUBLIC (3)			
	39.	Mr. Moukphamay Thammavongsa	Deputy Director of Air Navigation Standard Division, Department of Civil Aviation of Lao PDR	moukth@msn.com;

Note: * - Virtual Participant

ATTM. 1 - 4

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	40.	Mr. Kongsavanh Chanthavong	CNS Engineering, Lao Air Navigation Services (LANS)	Kongsavanh.lans@gmail.com;
	41.	Mr. Xaysavanh Kittanouvong	Deputy General Director of Lao Air Navigation Services	xays.kitta@gmail.com;
12.	MALAYSIA (6)			
	42.	Mr. Khairul Nazmi Zainol Ariffin	Principal Assistant Director , Civil Aviation Authority of Malaysia	k.nazmi@caam.gov.my;
	43.	Mr. Mohd Fitri Bin Ishak	Deputy Director, Civil Aviation Authority of Malaysia	fitri@caam.gov.my;
	44.	Mr. Shairyzal Mohamad @ Azizan	Assistant Director, Civil Aviation Authority of Malaysia	shairyzal.azizan@caam.gov.my;
	45.	Mr. Izad Redza	CNS-ATM Manager, Civil Aviation Authority of Malaysia	izad@aaf.my;
	46.	Mr. Mohd Fahmi bin Abd Aziz	Account Manager (Aviation), Civil Aviation Authority of Malaysia	mfahmi.aziz@tm.com.my;
13.	MALDIVES (1)			
	47.	Mr. Ishag Abdulla	General Manager, Air Traffic Engineering Maldives Airports Company Limited	ishag@macl.aero;
14.	MONGOLIA (1)			
	48.	Mr. Puntsag Ganbaatar	Senior Inspector, Civil Aviation Authority of Mongolia	ganbaatar@mcaa.gov.mn;
15.	MYANMAR (2)			

Note: * - Virtual Participant

ATTM. 1 - 5

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	49.	Mr. Zaw Min Oo	Deputy General Manager (CNS) Department of Civil Aviation, Myanmar	zawminoo76@gmail.com; zawminoo.cns@dcamyanmar.aero;
	50.	Mr. Yan Aung Oo	Deputy Director CNS Inspection Department of Civil Aviation, Myanmar	yanaungoo.nav@gmail.com;
16.	NEW ZEALAND (4)			
	51.	Mr. Edmund Heng	Technical Specialist Aeronautical Services, Civil Aviation Authority of New Zealand	edmund.heng@caa.govt.nz;
	52.	Mr. Andy Alford*	Senior ANS Operations (Surveillance) Specialist, Airways New Zealand	andy.alford@airways.co.nz;
	53.	Mr. Vaughan Hickford*	Team Leader Network Design, Airways New Zealand	vaughan.hickford@airways.co.nz;
	54.	Mr. Christopher Cloughley*	Software Engineer, Airways New Zealand	chris.cloughley@airways.co.nz;
17.	PHILIPPINES (1)			
	55.	Mr. Leandro Varquez	Department Manager Iii, Civil Aviation Authority of The Philippines (CAAP)	elbotvarquez@gmail.com;
18.	REPUBLIC OF KOREA (3)			
	56.	Mr. Kyungjoon JANG	Deputy director, KOCA, MOLIT, Republic of Korea	skyjjan@korea.kr;
	57.	Mr. Yonghee KWON	Assistant director, KOCA, MOLIT, Republic of Korea	kyh75@korea.kr;
	58.	Mr. Woncheol DO	Manager, Korea Airports Corporation	kacdwc@airport.co.kr;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
19.	SINGAPORE (4)			
	59.	Mr. Keng Boon Chew	Head (Communications), Civil Aviation Authority of Singapore (CAAS)	chew_keng_boon@caas.gov.sg;
	60.	Mr. Victor Lee	Principal Manager (CNS Regulation), Civil Aviation Authority of Singapore (CAAS)	victor_lee@caas.gov.sg;
	61.	Mr. Yi Wei Yeoh	Principal Manager (CNS/Met Regulation), Civil Aviation Authority of Singapore (CAAS)	yeoh_yi_wei@caas.gov.sg;
	62.	Mr. Kim Hee Chua	Deputy Director (CNS), Civil Aviation Authority of Singapore (CAAS)	chua_kim_hee@caas.gov.sg;
	63.	Mr. Ang Cheng How Aloysius	Head (Ops Tech Planning/Ops Tech Development), Civil Aviation Authority of Singapore (CAAS)	Aloysius_ang@caas.gov.sg;
20.	SRI LANKA (1)			
	64.	Mr. Chamara Liyanage	Senior Electronics Engineer, Airport and Aviation Services (Sri Lanka) Ltd.	chamara.eane@airport.lk;
21.	THAILAND (15)			
	65.	Mr. Sarawoot Rungruenwajiake	Head of Communications Navigation and Surveillance Standards Division, CAAT	Sarawoot.r@caat.or.th;
	66.	Mr. Chavalit lthiapa	Communications Navigation and Surveillance Standards Officer, CAAT	Chavalit.i@caat.or.th;
	67.	Mr. Thamawoot Pocathikorn	Communications Navigation and Surveillance Standards Officer, CAAT	Thamawoot.p@caat.or.th;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	68.	Mr. Chaiwat Saekhew	Officer, The Civil Aviation Authority of Thailand	chaiwat.s@caat.or.th;
	69.	Mr. Wittaya Chunvattanananon*	Senior Director, Aerothai, Aeronautical Radio of Thailand Ltd.	chun@aerothai.co.th;
	70.	Mr. Chonlawit Banphawatthanarak	Expert, Director Level , Aerothai	chonlawit.ba@aerothai.co.th ;
	71.	Mr. Chainan Chaisompong	Air Traffic Engineering Manager , Aeronautical Radio of Thailand Limited (Aerothai)	chainan.ch@aerothai.co.th;
	72.	Ms. Amornrat Jirattigalachote*	Strategic Planning Manager (Engineering), Aeronautical Radio of Thailand Ltd. (Aerothai)	amornrat.ji@aerothai.co.th;
	73.	Mr. Pattharasit Phankrawee*	Acting Director, Air Traffic Surveillance Systems Engineering Department, Aeronautical Radio of Thailand Ltd. (AEROTHAI)	phankrawee@gmail.com;
	74.	Mr. Pramuk Rungrojaree	Air Traffic Engineering Manager, Aerothai, Aeronautical Radio of Thailand Ltd.	pramuk.ru@aerothai.co.th;
	75.	Mr. Nattapong Siansawasdi	Executive Air Traffic Systems Engineer, Air Traffic Navigation Systems Engineering Department Aeronautical Radio of Thailand Ltd.	nattapong.si@aerothai.co.th;
	76.	Mr. Pakkawin Watcharakhajonwong	Senior Air Traffic Systems Engineer, Aerothai, Aeronautical Radio of Thailand Ltd.	pakkawin.wa@aerothai.co.th;
	77.	Mr. Wittawat Kantat	Air Traffic Engineering Manager, Aerothai	wittawat@aerothai.co.th;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	78.	Mr. Chanyut Phrukumwong	Director, Air Traffic Services Engineering Research and Development, Aerothai	
	79.	Ms. Sawaluck Teerapanpong*	Air Traffic Engineer, Aerothai, Aeronautical Radio of Thailand Ltd.	sawaluck.te@aerothai.co.th;
22.	TONGA (1)			
	80.	Mr. Sione Feiloakitau Takapautolo	Chief Technical and Support Officer, Tonga Airport Limited	stakapautolo@tongaairports.com;
23.	USA (4)			
	81.	Mr. Ahmad Usmani	Manager, Asia Pacific Group Federal Aviation Administration Air Traffic Organization, System Operations ATO International Office	ahmad.usmani@faa.gov;
	82.	Mr. Shayne A. Campbell	Senior Air Traffic Representative, Asia Pacific Federal Aviation Administration Air Traffic Organization, Mission Support	shayne.a.campbell@faa.gov;
	83.	Mr. Hoang Tran	International Telecommunications Lead Federal Aviation Administration	hoang.tran@faa.gov;
	84.	Mr. Alejandro Alex Rodriguez*	Technical Advisor – Surveillance Air Traffic Organization - Program Management Office Federal Aviation Administration	alejandro.rodriguez@faa.gov;
24.	VIET NAM (10)			
	85.	Mr. Ho Sy Tung	Deputy Director General of VATM	tunghosy@vatm.vn;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	86.	Mr. Tuan Vu Ngoc	CNS Official, Civil Aviation Authority of Viet Nam	vungoctuan@caa.gov.vn;
	87.	Mr. Pham Hung Son	Deputy Director of CNS Dept., Viet Nam Air Traffic Management Corporation (VATM)	sonph@vatm.vn;
	88.	Mr. Nguyen Khanh Linh	Technical Department Specialist, Vietnam Air Traffic Management Corporation	linhnhk@vatm.vn;
	89.	Mr. Son Le Vu Truong	Deputy Manager, Airfield Operation Center - Tan Son Nhat International Airport	lvtruongson@yahoo.com;
	90.	Mr. Thach Canh Hai	Deputy Manager of Airport Operation Department, Airports Corporation of Vietnam	thachcanhhai@gmail.com;
	91.	Mr. Cuong Nguyen Manh	Airfield Devices Maintenance Engineer, Airports Corporation of Viet Nam (ACV)	cuongbk56@gmail.com;
	92.	Mr. Nguyen Ngoc Quynh	Specialist, Airports Corporation of Viet Nam (ACV)	quynhnn@acv.vn;
	93.	Mr. Thanh Hai Le Tu	Manager, Danang International Airport	ltthai@vietnamairport.vn;
	94.	Mr. Tu Thanh Hai Le	Manager, Danang International Airport, Vietnam	hailtt@acv.vn;
25.	IATA (4)			
	95.	Mr. Diego Albert	Regional Assistant Director Operations, Safety And Security, International Air Transport Association (IATA)	albertd@iata.org;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	96.	Mr. George Chan	Regulatory Affairs Manager - Operations And Industry, IATA	george_g_chan@cathaypacific.com;
	97.	Ms. Kananuch Wichitnark	Senior Chief (Specialist), Dispatch & Charter Services THAI Operations Control Center (TOCC)	kananuch.w@thaismileair.com;
	98.	Mr. Watcharin Thongthubthim	Flight Operations Officer THAI Operations Control Center (TOCC)	watcharin.th@thaismileair.com;
26.	IFATSEA (1)			
	99.	Mr. Senthilvel Balasubramanian	Regional Director, APAC International Federation of Air Traffic Safety Electronics Associations (IFATSEA)	senthilvel.balasubramanian@ifatsea.org;
27.	FREQUENTIS (1)			
	100.	Mr. Ulrich "Uli" Kaage*	ATM Data Solutions Consultant, Frequentis	Ulrich.KAAGE@frequentis.com;
28.	SAAB (1)			
	101.	Mr. Fredrik Lindblom*	Country Manager Thailand SAAB	fredrik.lindblom@saabgroup.com;
29.	ICAO (7)			
	102.	Mr. Peter Dunda	Regional Officer MET/ENV International Civil Aviation Organization Asia and Pacific Office	pdunda@icao.int;
	103.	Mr. Takata Hiroyuki	Regional Officer ATM International Civil Aviation Organization Asia and Pacific Office	htakata@icao.int;

Note: * - Virtual Participant

CNS SG/27
Attachment 1 to the Report

	STATE/NAME		TITLE/ORGANIZATION	E-MAIL
	104.	Mr. Vijay Kumar Mishra	Regional Officer PBN Asia & Pacific Regional Sub-Office (APAC RSO)	vkmishra@icao.int;
	105.	Mr. Luo Yi	Regional Officer CNS International Civil Aviation Organization Asia and Pacific Office	yluo@icao.int ;
	106.	Ms. Soniya Nibhani	Regional Officer ANS (CNS) Implementation International Civil Aviation Organization Asia and Pacific Office	snibhani@icao.int;
	107.	Ms. Zhong Wenhan	Regional Officer CNS International Civil Aviation Organization Asia and Pacific Office	wzhong@icao.int;
	108.	Ms. Varapan Meefuengsart	Programme Assistant International Civil Aviation Organization Asia and Pacific Office	vmeeфуengsart@icao.int;

Note: * - Virtual Participant

LIST OF WORKING/INFORMATION PAPERS/FLIMSIES/PRESENTATIONS

WP/IP/SP Number	Agenda	Subject	Presented by
WORKING PAPERS			
WP/01	1	Provisional Agenda	Secretariat
WP/02	2	Review Outcomes of 41st Session of the Assembly	Secretariat
WP/03	2	CNS SG/26 and APANPIRG/33 Conclusions/Decisions and Action Items	Secretariat
WP/04	2	Outcomes of the First Meeting of the Asia and Pacific (APAC) Air Navigation Service Provider (ANSP) Committee (AAC/1)	Secretariat
WP/05	2	Air Traffic Management and Airspace Safety Monitoring Outcomes	Secretariat
WP/06	2	Review Relevant Outcomes of the MET SG	Secretariat
WP/07	3.1	Review Report of the Tenth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/10)	Secretariat
WP/08	4.0	Review Report of the Seventh Meeting of System Wide Information Management Task Force (SWIM TF/7)	Secretariat
WP/09	5.1	Report of Workshop on ITU World Radiocommunication Conference 2023 (WRC-23 Workshop) / Regional Preparatory Group (RPG) Meeting for WRC-2023	Secretariat
WP/10	5.2	Review Report of the Seventh Meeting of Spectrum Review Working Group (SRWG/7)	Secretariat
WP/11	6.1	Review Report of the Tenth Meeting of Performance Based Navigation Implementation Coordination Group (PBNICG/10)	Secretariat
WP/12	6.2	Review Report of the Fifth Meeting of GBAS/SBAS Implementation Task Force (GBAS/SBAS LTF/5)	Secretariat
WP/13	6.3	Revised Navigation Strategy for Asia Pacific Region	Secretariat
WP/14	7.1	Outcomes of the Eighth Meeting of the Surveillance Implementation Coordination Group (SURICG/8)	Secretariat
WP/15	8.1	Review Outcomes of the Seminar on Air Traffic Management Automation System and the Fourth Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (ATMAS TF/4)	Secretariat
WP/16	9.1	Progress on APAC Seamless ANS Reporting Portal	Secretariat

CNS SG/27
Attachment 2 to the Report

WP/IP/SP Number	Agenda	Subject	Presented by
WP/17	9.4	Achieving High Resilience in Sustaining Operations of Critical Aeronautical Infrastructure	Hong Kong, China
WP/18	9.4	Beijing Declaration Implementation in CNS	Secretariat
WP/19	10	Review Status of CNS Deficiencies	Secretariat
WP/20	11	Review Outcomes of Small Working Group Study on Human Factor Issues of ATSEP	IFATSEA
WP/21	11	Implementation Support Project in Lao People's Democratic Republic (Lao PDR) ATM Infrastructure Operations Capability Building	Secretariat
WP/22	9.1	Repository of AIDC Implementation Status in APAC	Secretariat
WP/23	13	Uniting the Strength of Innovation for Building a Seamless Sky - the Asia Pacific Region Innovation & Capacity Building Symposium 2023 (APICS 2023)	Hong Kong, China on behalf of the Organizing Committee of APICS 2023
WP/24	14	Comments/Feedback on Asia Pacific Ministerial Declaration on Civil Aviation (Delhi)	Secretariat
WP/25	14	CNS Points of Contact	Secretariat
WP/26	6.4	Managing Challenges of IN-SITU Replacement for Instrument Landing Systems at the World's Busiest Cargo Airport	Hong Kong, China
WP/27	5	Report from CP-DCIWG-WG-M/1 Meeting	Rapporteur of CP-DCIWG-WG-M
WP/28	9.1	Asia/Pacific Seamless ANS Plan Update	Secretariat
WP/29	3.2	Challenges and Requirements for IPS Environment	USA / Federal Aviation Administration
WP/30	5.3	Space-Based Very High Frequency (VHF) Communication Services	Singapore
WP/31	9.1	Updates on Regional CNS Requirements in ICAO APAC e-ANP	Secretariat
WP/32	4	Multi-Regional TBO Demonstration	Japan, Singapore, Thailand, and USA
WP/33	6.4	Feasibility Study and Trial of Using Drone to Enhance Efficiency in Flight Inspections at the Hong Kong International Airport	Hong Kong, China
WP/34	3	Current Status of CRV Implementation in India	Secretariat

CNS SG/27
Attachment 2 to the Report

WP/IP/SP Number	Agenda	Subject	Presented by
INFORMATION PAPERS			
IP/01	-	Meeting Bulletin	Secretariat
IP/02	5.4	Guidance Material on the Protection of Radio Altimeter from Potential Harmful Interference from Cellular 5G Communications	Secretariat
IP/03	15.0	CNS Meeting Planning for 2024	Secretariat
IP/04	13	Update on the Implementation of the ICAO Secretariat Strategy on Innovation	Secretariat
IP/05	7.2	Implementation of ADS-B Verification Technologies for Operational Surveillance System in Japan	Japan
IP/06	7.2	The Importance of Preparation of Emergency Equipment for ATC as Risk Management	Japan
IP/07	13	The Long-Term Vision for The Future Air Traffic Systems of Japan (CARATS)	Japan
IP/08	11	ATSEP Competency Based Training in ATMB and CAAC	China
IP/09	6	BDS Standardization Status in ICAO	China
IP/10	6.4	Research on BDS ISM Broadcast Scheme	China
IP/11	5.3	LDACS Development in China	China
IP/12	5.0	New-Generation AeroMACS Project Progress in China	China
IP/13	5.0	Progress on VHF Com Frequency Allotment Plan for APAC Region	China
IP/14	3.2	Distribution of XML Based Messages in AMHS and SWIM Environment	USA/Federal Aviation Administration
IP/15	5.1	Outcome of APG23-6 Meeting	Secretary of the Trust Framework Panel
IP/16	12.1	Update on Trust Framework Activities	Secretary of the Trust Framework Panel
IP/17	4.2	Outcomes of System Wide Information Management Seminar	Secretariat
IP/18	11	Technical Assistance Project ATM Infrastructure Operations Capability Building	Lao PDR
IP/19	6.4	Korea Augmentation Satellite System (KASS) Status	Republic of Korea

CNS SG/27
Attachment 2 to the Report

WP/IP/SP Number	Agenda	Subject	Presented by
IP/20	6.4	Navigational Aids Check by Using Drone in Republic of Korea	Republic of Korea

PRESENTATIONS

SP/01		Global Developments Related to CNS	Secretariat
SP/02	9.1	Asia Pacific Seamless ANS Plan	Secretariat
SP/03	11	Implementation Support Project In Lao People's Democratic Republic (Lao PDR) ATM Infrastructure Operations Capability Building	Secretariat
SP/04	9.1	Repository of AIDC Implementation Status in APAC	Secretariat
SP/05	11	Review Outcomes of Small Working Group Study on Human Factor Issues of ATSEP	IFATSEA
SP/06	9.4	Achieving High Resilience in Sustaining Operations of Critical Aeronautical Infrastructure	Hong Kong, China
SP/07	13	Uniting the Strength of Innovation for Building a Seamless Sky – The Asia Pacific Region Innovation & Capacity Building Symposium 2023 (APICS 2023)	Hong Kong, China
SP/08	7.1	Outcomes of the Eight Meeting of the Surveillance Implementation Coordination Group (SURICG/8)	SURICG Co-Chair
SP/09	6.4	Managing Challenges of IN-SITU Replacement for Instrument Landing System at the World's Busiest Cargo Airport	Hong Kong, China
SP/10	6.4	Feasibility Study and Trial of Using Drone to Enhance Efficiency in Flight Inspections at the Hong Kong International Airport	Hong Kong, China
