



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

**REPORT OF
TWENTY SIXTH MEETING OF THE
COMMUNICATIONS/NAVIGATION AND SURVEILLANCE SUB-GROUP
(CNS SG/26) OF APANPIRG**

Video Tele-Conference (VTC)

5 - 9 September 2022

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/33 Meeting and any formal action taken will be published in due course as a Supplement to the Report of the APANPIRG Meeting.

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1. Introduction

1.1 The Twenty Sixth Meeting of the Communications, Navigation and Surveillance Sub-group (CNS SG/26) of Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG), was held from 5 to 9 September 2022 via Video Tele-Conference (VTC) using Microsoft Teams.

2. Attendance

2.1 The meeting was attended by **247** participants from **26** States/Administrations (Afghanistan, Australia, Bangladesh, Bhutan, Cambodia, China, Hong Kong China, Macao China, France, Fiji, India, Indonesia, Japan, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, USA, Viet Nam), **4** International Organizations namely CANSO, IATA, ICAO and IFATSEA, including **21** 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 gave a special greeting to the chairpersons of various contributing bodies to the CNS SG. He highlighted some 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. He extended his thanks and appreciation to the excellent leadership and significant contribution of Mr. Richard Wu, Chair of CNS SG, in steering the work of the CNS Sub-group along with his commitment and support to this Sub-group.

3.2 Mr. Richard Wu, the Chair of CNS SG of APANPIRG, welcomed all participants and shared the honour to continue serving as the Chairperson of the CNS Sub-group. He informed about the IATA forecast about total air passenger numbers in 2022 and 2023, indicating that traffic to be recovered back to 83% and 94% respectively of pre-pandemic level along with fluid and unpredictable pace for recovery of international air traffic. Furthermore, he shared various accomplishments of CNS SG along with its contributory bodies. He hoped to have a solid foundation to pave the way for a smooth recovery in terms of safe and reliable CNS infrastructure and services. He expressed appreciation to the contribution from the ICAO Bangkok Office, under the able leadership of the Regional Director, in organizing a large number of online meetings conducted in the last year and shared the significant accomplishments made by APAC members. Lastly, he shared the confidence to have another successful CNS Sub-group meeting with the strong support from the ICAO Regional Office and the active participation from members and aviation partners in surpassing the challenges.

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, ICAO APAC Regional Office, acted as the secretaries of the meeting with the support of Mr. How Sze Lung, Regional Officer CNS, Ms. Zhong Wenhan, Regional Officer CNS, and Ms. Thita Pongdara, the Programme Assistant of the same office. The meeting was also supported by Regional Officers, ATM and MET of ICAO APAC Regional Office, Bangkok, Thailand, PBN Officer of 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 inclusive of all documentation and this Report. The Sub-group met as a single body to deal with all the agenda items.

5.2 The meeting considered **34** Working Papers, **23** Information Papers, and **6** 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, Sub-groups are empowered to adopt Conclusions and Decisions on technical matters (especially those concerning guidance to States in the implementation of ICAO SARPs, GANP, RANP, and Seamless ANS Plan).*

Reference	Subject	Page
Draft Conclusion CNS SG/26/01 (ACSICG/09/01 (CRV OG/09/01))	- Revised Amendment of the Management Service Agreement for CRV project (RAS14801)	4
Draft Conclusion CNS SG/26/02 (ACSICG/09/02 (CRV OG/10/01))	- Extension of CRV Contract for one year.	5
Conclusion CNS SG/26/03 (ACSICG/09/04)	- Revised AFTN/ATSMHS Routing Directory	7
Decision CNS SG/26/04 (SWIM TF/06/01))	- The Use of the Internet for MET Information Services in Regional SWIM architecture	12
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Conclusion CNS/SG/26/09	- Update of Flight Inspection Guidance Material (FIGM)	31
Conclusion CNS SG/26/10 (SURICG/7/1 (DAPs WG/5/1))	- Mode S DAPs IGD 4.0	33
Draft Conclusion CNS SG/26/11 (SURICG/7/3)	- Revised Surveillance Strategy for the APAC Region	38
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Conclusion CNS SG/26/13 (ATMAS TF/3/1)	- ATMAS IGD Edition 1.0	44

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 APANPIRG/RASG Chairpersons review, APANPIRG/32 meeting, DGCA/57 meeting, ATM Sub-group and other major meetings relevant to CNS Sub-group

Outcomes of APANPIRG/32, RASG-APAC/11, APANPIRG/32 Midyear Review and 9th PIRG-RASG Coordination Meeting on CNS- Sec (WP/02)

- 2.1 APANPIRG/32 was held from 1 to 3 December 2021 via VTC. The meeting discussed CNS related matters and took subsequent actions on CNS SG/25 meeting report and other papers presented under Agenda Item 3.4. The APANPIRG/32 noted that CNS SG/25 meeting had adopted **8** Conclusions and **5** Decisions on technical and operational matters, and proposed **4** Draft Conclusions for APANPIRG/32 adoption, which were adopted by the APANPIRG/32.

- 2.2 APANPIRG/32 Midyear Review and 9th Planning and Implementation Regional Group-Regional Aviation Safety Group (PIRG-RASG) Regional Coordination Meeting were held on 2 August 2022 via VTC. APANPIRG/32 Midyear Review meeting discussed APAC key challenges in Air Navigation, key outcomes and achievements, updates on APANPIRG/32 Action Plan and outstanding APANPIRG Conclusions/Decisions Action Plan.

- 2.3 RASG-APAC/11 was held from 4 to 5 December 2021 via VTC. The meeting discussed 1 Conclusion and 1 Decision regarding potential interference to aircraft radio altimeter by 5G telecommunications system.

Updates on CNS SG/25 and APANPIRG/32 Conclusions/Decisions, and Action Items- Sec (WP/03)

- 2.4 The meeting noted the latest status for various Conclusions/Decisions adopted in the CNS SG/25, Conclusions/Decisions adopted in the APANPIRG/32 related to CNS along with latest status and action taken on various ACTION ITEMS formulated by the CNS SG/25 meeting.

Relevant Action Items of 57th Conference of Directors General of Civil Aviation-Sec (WP/04)

- 2.5 The 57th Conference of Directors General of Civil Aviation (DGCA Conf/57), APAC, was hosted by Republic of Korea in Incheon from 4 to 8 July 2022. Total 503 participants with 302 attending in-person and 201 online, from 31 States/Administrations and 11 International Organizations participated the meeting. With the theme *“Strengthening regional cooperation for the restoration of air network with No Country Left Behind”*, 84 Discussion Papers were presented and 48 Information Papers were submitted under 11 Agenda Items in the Conference. The Conference formulated 64 Action Items. All Papers related to CNS were listed in the paper, and various Action Items related to CNS are provided in an appendix to the paper. States/Administrations were urged to take follow-up actions and provide ICAO APAC Office a status report of implementation in timely manner.

- 2.6 The meeting noted that the 58th Conference of Directors General of Civil Aviation (DGCA Conf/58) will be hosted by Bangladesh in 2023 with the theme *“Promoting ICAO Gender Equality Programme in conjunction with Next Generation of Aviation Professionals (NGAP) initiative”*. The conference was informed that India will host the Second Asia Pacific Ministerial Conference in early 2023. The Second Asia Pacific Ministerial Conference is expected to deliver renewed commitments from the Asia Pacific Aviation Ministers in the new regional aviation landscape

in the post-pandemic era.

Air Traffic Management and Airspace Safety Monitoring Outcomes- Sec (WP/32)

2.7 The paper presented key outcomes from the technical working groups established under the oversight of the Air Traffic Management and Regional Airspace Safety Monitoring Advisory Sub-Groups of APANPIRG, and other information relevant to CNS Sub-Group.

2.8 The CNS SG/26 meeting noted the outcomes of the Ninth Meeting of the Air Traffic Management Sub-Group of APANPIRG (ATM/SG/9) held from 01 to 05 November 2021, the first Meeting of the South Asia, Indian Ocean and Southeast Asia ATM Coordination Group (SAIOSEACG/1, 28 March to 01 April 2022), the Seventeenth Meeting of the Aeronautical Information Services (AIS)- Aeronautical Information Management (AIM) Implementation Task Force (AAITF/17, 20 to 24 June 2022), and the Twenty-Seventh Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/27) held by video teleconference from 22 to 25 August 2022. The meeting was informed that the Air Traffic Flow Management (ATFM) and Airport Collaborative Decision-Making (A-CDM) Webinar and Twelfth Meeting of the ATFM Steering Group will be held from 12 to 16 September 2022. Additionally, ATM/SG/10, scheduled to be held from 17 to 21 October 2022, which will review the outcomes of all abovementioned meetings.

2.9 Several ICAO Activities in the field of Unmanned Aircraft were shared. The meeting was requested to take advantage of the large volume of guidance on UAS, and participate in the ICAO Unmanned Aviation 2022 symposia to be held at ICAO Headquarters, Montreal, Canada, from 07 to 09 November 2022. The theme of the symposium is *To Certify or Not to Certify*.

2.10 The meeting was informed about the Safety Report by the Asia/Pacific RMAs and En-route Monitoring Agencies (EMA)s and special attention on current Large Height Deviation (LHD) Hot Spots, the FIRs involved, the year of identification, and status remarks. It was added that CNS SG should note that although Air Traffic Services (ATS) Inter-facility Data Communication (AIDC) is not a new technology, it can be a significant mitigation of LHD incidents. However, there appeared to be cases where alerts to controllers when AIDC messaging had failed may have been either not presented, not seen, or not responded to. Additionally, At the RASMAG/27 meeting, IFATCA stressed the need for robust ATC training to ensure compliant use of new technology and application of contingency procedures when system operation failed.

2.11 The CNS SG Chair suggested the ICAO Secretariat prepares a joint CNS-ATM working paper to highlight the issue and present it to the fourth meeting of the APAC Automation Task Force (ATMAS TF/4) **ACTION ITEM 26-1**.

Review of Regional ATFM Framework and Guidance Material

2.12 The meeting was informed that a major review of the Regional Framework for Collaborative ATFM will be presented for consideration by the ATFM/SG/12 meeting. CNS SG was invited to note that the Framework includes information and regional performance expectations relating to the use of FIXM for the cross-border exchange of ATFM information, and the use of AFTN messaging where the exchange of information using FIXM is not yet enabled. The meeting was further invited to note the necessary close collaboration between ATFM/SG, the SWIM TF (APAC FIXM Extension development) and ACSICG (ATFM information exchange by AFTN).

Agenda Item 3: Aeronautical Fixed Service (AFS)

3.1 Under this agenda, the meeting reviewed meeting reports of a number of contributory bodies on the AFS matters.

Review the Report of the Ninth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/9) - Sec (WP/05)

3.2 The paper presented the discussions and relevant outcomes of the Ninth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/9) held *from 19 to 21 April 2022*. ACSICG/9 meeting report, working papers, information papers, and other resources can be accessed by following link:

<https://www.icao.int/APAC/Meetings/Pages/2022-ACSICG9.aspx>

3.3 The meeting reviewed various topics discussed in ACSICG/9, updated the AMHS/ATN implementation status in States, reviewed the outcomes of CRV OG/9 and CRV OG/10 meetings which included discussions on the Upgrade/Downgrade CRV Circuits Subscribed and Contract Extension requirements, discussed and addressed the implementation issues, reviewed ATN Table Tree and AMHS/AFTN Communication Chart, further explored Inter-regional AFS connection, and shared experience on AFS related cybersecurity issues.

Updates on CRV Pioneer State Contribution to the ICAO Managed Service Agreement (MSA)

3.4 The ICAO Secretariat informed the meeting in CRV OG/2 about the fund balance of USD 104,596 and proposed a draft of revision of Annex 1b to the MSA, and adopted by APANPIRG/28 as Conclusion APANPIRG/28/19: *Amendment of the Management Service Agreement for CRV project (RAS14801)* which remains as one of outstanding Conclusions/Decisions up to APANPIRG/32 held in December 2021. The paper presented an update on the relevant development of using the balance of the MSA.

3.5 With the efforts of the ICAO Secretariat, ICAO TCB, CRV OG co-chairs and ACSICG Chair, the Revised Annex 1 to Management Service Agreement (MSA) was prepared that the fund will be utilised in the span of 5 years starting from 31 March 2022 to 31 March 2027. The CRV OG/9 meeting requested Member States to provide examples of activities under different categories provided in scope of supporting CRV Network as described in section 10.5 as an action item of CRV OG/9.

3.6 With aforementioned, the following draft conclusion for the next step for using the rest of CRV Pioneer State Contribution to the ICAO Managed Service Agreement (MSA) proposed by CRV OG/9 and ACSICG/9 was endorsed by CNS SG/26 for APANPIRG/33 consideration.

Draft Conclusion CNS SG/26/01 (ACSICG/09/01 (CRV OG/09/01)): Revised Amendment of the Management Service Agreement for CRV project (RAS14801)		
What:	Recognizing that ICAO Technical Cooperation Bureau satisfactorily completed all the defined work items in the initial Management Service Agreement (MSA) and Project Document of RAS14801, that the required payments were settled, and that in end 2016, all the requirements of both parties have been fully completed and closed on record, That,	Expected impact:
i) all Pioneer States are encouraged to counter-sign the Revised amended Pro Document provided in Appendix A to the report;		☐ Political / Global
ii) any Pioneer State not countersigning is entitled to get its share of the remaining fund balance back. and		☐ Inter-regional
		☒ Economic
		☐ Environmental
		☒ Ops/Technical

iii) a Pioneer State for which a direct CRV connection is not considered feasible in 2017 by the selected vendor is entitled to get its initial contribution in full	
Why: The initial scope of MSA was completed by ICAO TCB which allowed for a successful evaluation process and selection of a best and final offer; a majority of Pioneer States is willing to use the rest of their initial contribution to continue to support CRV implementation.	Follow-up: ☒ Required from States
When: 09-Sep-22	Status: Draft to be adopted by PIRG
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:	

3.7 This draft conclusion will be presented to APANPIRG/33 and may supersede outstanding Conclusion APANPIRG/28/19: *Amendment of the Management Service Agreement for CRV project (RAS14801)*.

Proposal to Extend CRV Contract

3.8 As a follow up action of ACTION ITEM 9-4 of CRV OG/9, the ICAO APAC Office issued a State Letter to request States/Administrations to share the intention to join CRV and its Tentative Timelines. In response, total **13** (thirteen) Member States shared their intention to join CRV along with tentative timelines, including 10 (ten) States/Administration intend to join CRV by Q4 2022, 2 (two) States intend to join CRV after Q4 2022, and 1 (one) State has no plan yet.

3.9 To follow up ACTION ITEM 9-5 of CRV OG/9, the first meeting of ICAO CRV Steering Group created by CRV OG/9 was held on 31 March 2022. The meeting reviewed the responses received from Member States, discussed the requirement of additional efforts to support pacific Member States to join CRV, and advised to extend the contract duration for **one additional year**.

3.10 Based on the proposal of draft conclusion by CRV OG/10, the ACSICG/9 and CNS SG/26 meeting endorsed the following draft conclusion for the consideration of APANPIRG/33 meeting. If adopted, the ICAO Secretariat will inform Member States about the extension of the current contract on the same Terms and Conditions.

Draft Conclusion CNS SG/26/02 (ACSICG/09/02 (CRV OG/10/01)): Extension of CRV Contract for one year	
What: a) Recognizing that as per current contract, all authorities shall join the CRV project and sign the relevant Service Contract(s) with PCCWG with the billing start date on or before 31 December 2022 to not impose additional charges by the service provider and based on the survey responses of 2022, many Member States are in process to join CRV which may not be completed by December 2022, it is recommended to extend current CRV contract for one year. b) If agreed to extend, as per amended CRV contract, all authorities shall join the CRV program and sign the relevant Service Contract(s) with PCCWG with the billing start date on or before 31 December 2023 to not impose additional charges by the service provider. c) After the extension, the CRV contract expiry date will be 31 December 2028.	Expected impact: ☐ Political / Global ☐ Inter-regional ☒ Economic ☐ Environmental ☒ Ops/Technical

Why: Several ICAO Member States have requested to extend CRV contract due to COVID-19 pandemic in CRV Implementation webinar held in 2021 and based on the response of the survey done in 2022, many Member States are in process to join CRV which may not be completed by December 2022.	Follow-up: ☒ Required from States
When: 09-Sep-22	Status: Draft to be adopted by PIRG
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:	

3.11 Singapore queried for the rate for additional one year term after CRV contract extension. The meeting was informed that the current contract extension will be based on same terms and conditions and rates. After initial five years term, States may renew the CRV contract on yearly basis till expiry of the contract. However, States and PCCWG may negotiate bilaterally for better rate to renew the contract for more than one year. Nevertheless, the last date of contract cannot exceed CRV contract expiry date.

Upgrade/Downgrade/Addition of New Services or Sites in CRV Contract

3.12 In the first meeting of ICAO CRV Steering Group held on 31 March 2022, PCCWG shared the revised proposal for upgrade/downgrade/addition of new sites and services with reasonable pre-estimate of the anticipated losses suffered by PCCWG.

3.13 The revised proposal **withdraw cancellation charges and mandate of five years term** for each **upgrade** case and **addition of new sites/services**. Therefore, Member States may upgrade or add new sites or services in their contract without any additional charges or additional terms on the same rate. The revised proposal recommended to calculate **pre-estimate of the anticipated losses** suffered by PCCWG by a proposed formula in case of **downgrade** and proposed to share the anticipated losses between PCCWG and States equally. Additionally, the mandate of five years terms for downgrade cases was withdrawn. Therefore, Member States may downgrade the current package in their contract with additional charges of 50% of **the anticipated losses** but without additional terms on the same rate.

3.14 The proposal was accepted by all members of CRV Steering group for submission to CRV OG/10 deliberation and agreement. The CRV OG/10 meeting held on 18 April 2022 deliberated and reviewed the proposal submitted by PCCWG for upgrade/downgrade/addition of new services or site into current CRV Contract, and endorsed the proposal to work further for revision of relevant documentation of CRV common package.

3.15 To respond to an enquiry, PCCWG informed that the formalization of the proposal would be ready tentatively by May 2022. The ICAO Secretariat added that next ICAO CRV Steering group will review and discuss the phrasings of revised terms and conditions prepared by PCCWG in July 2022 which was postponed to be discussed on 15 September 2022. The revised common package would be presented to CRV OG/11 for endorsement and approval. However, the presented proposal is applicable immediately after the endorsement by CRV OG/10.

3.16 New Zealand informed that the current DRAFT version of the Operations Manual is ready for publication as version 1.1. The updates in different sections were explained in detail in this paper. It was added that Member States can request access to the manual by requesting access to the portal by following the steps mentioned on [CRV Landing Page: http://www.icao.int/APAC/Pages/Join-CRV.aspx](http://www.icao.int/APAC/Pages/Join-CRV.aspx)

3.17 Based on the proposal by CRV OG/10, the ACSICG/9 meeting adopted the Decision ACSICG/09/03 - Publication of the ICAO APAC CRV OG Operations Manual v1.1.

3.18 The State Letter **Ref:** T 8/9.1 – AP077/22 (CNS) with Subject of *Publication of CRV OG Operations Manual v1.1* has been issued on 24th May 2022 to urge States/Administrations to reference this manual for implementation of the CRV.

APAC AMHS Implementation Status from AMC

3.19 Thailand presented the AMHS implementation status information in Asia/Pacific Region updated in ATS Messaging Management Centre (AMC) in Attachment A of the paper through WP/05. AMC was implemented by EUROCONTROL to provide off-line network management services in support of the ground ATS Messaging network of Air Navigation Service Providers (ANSPs). The meeting was invited to review and update information to AMC via AEROTHAI if necessary, including points of contact in record.

AFTN/ATSMHS Routing Directory and the Communication Chart

3.20 The Secretariat presented the current status of the AFTN/ATSMHS routing directory and the latest Communication Chart for Asia and Pacific Regions in WP/12. The ACSICG/9 meeting was informed that the CNS SG/23 meeting agreed to fully follow the AFTN/ATSMHS routing directory during the transition period by end of 2020.

3.21 The meeting highlighted the any to any connectivity for IP network, as well as the reality that not all APAC States have joined CRV, while automation systems still heavily depend on the character-based message exchanging applications, this hybrid environment might keep on existing and there was not yet a clear timeframe for a full transition to CRV. As such, the ACSICG/9 meeting **agreed to fully follow the AFTN/ATSMHS routing directory** for present time in APAC region. For inter-regional traffic, it is required to follow the existing entry/exit points and procedure.

3.22 The meeting was informed that the updates would be published as 29th edition of AFTN/ATSMHS Routing Directory after adoption. Subsequently ACSICG/9 endorsed the Draft Conclusion for consideration by CNS SG/26, which was adopted by CNS SG/26. The adopted AFTN/ATSMHS Routing Directory is provided in **Appendix B** to the report.

Conclusion CNS SG/26/03 (ACSICG/09/04) - Revised AFTN/ATSMHS Routing Directory	
What: That, the AFTN/ATSMHS Routing Directory for the APAC Region provided in Appendix B to the report be further updated and distributed to States/Administrations as 29 th Edition.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: A number of new ATSMHS connections have been established and became operational. Consequential amendments to the AFTN/ATSMHS Routing Directory are required.	Follow-up: ☐ Required from States
When: 9-Sep-22	Status: Adopted by Subgroup
Who: ☒ CNS SG ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other:	

MPLS/IP Based Inter-Regional Connection

3.23 The Secretariat provided current status of discussion being done for potential interconnection of CRV and REDDIG II and CRV and New PENS, including the final technical proposal for interconnection of CRV and REDDIG II and business models to way forward. It also requested APAC Member States to record their interest, willingness, or need for interconnection of the CRV with other regional networks such as REDDIG II / New PENS with the ICAO Secretariat.

3.24 As the technical proposal for interconnection of CRV and REDDIG II is ready, the two potential business solutions for the proposed interconnection were proposed by the ICAO Secretariat for meeting consideration regarding approximately infrastructure cost and revised recurring charges. The ICAO Secretariat also informed that the ICAO APAC Office and ICAO EUR/NAT Office coordinated internally as well as with the service providers of regional network in respective regions. The outcomes of the discussions between PCCWG, the CRV service provider, and British Telecom, the New PENS service provider, and the internal meeting of British Telecom, EUROCONTROL and ANSPs were shared.

3.25 The ACSICG/9 meeting agreed to form an Ad-Hoc group comprised of APAC Member States having interregional connections, CRV OG Chairs, CRV and REDDIG II service providers, interested Member States of SAM region, and the ICAO Secretariat under CRV OG. The ICAO Secretariat will coordinate with relevant APAC Member States to nominate focal points for Ad-Hoc group. The ICAO Secretariat will coordinate with ICAO SAM Office to get nomination from interested SAM Member States for this task.

Aeronautical Fixed Service (AFS) Cybersecurity Considerations for Information over CRV

3.26 Some interim security considerations for CRV were presented, including Digital Identity and Network Information Security, prior to International Aviation Trust Framework (IATF) to be implemented in future. It further introduced the requirements for IATF Digital Identity concept uses Public Key Infrastructure (PKI) Digital Certificates, Network Information Security which includes the use of IPv6, Domain Name System (DNS), information security, network management and network contingencies, and SWIM interchanges with external entities.

3.27 The ICAO Secretariat shared that the interim measures proposed in the paper is more tangible and implementable comparing high level concepts, which can be considered as a useful reference for the CRV OG Operations Manual. While CRV OG and SWIM TF have their corresponding action items, the Co-Chairs noticed that the XML-based messages may compromise automation systems and it would be necessary to formulate managing plans to address the possible threat in cybersecurity. The ICAO Secretariat suggested to add a regular Agenda Item for ACSICG meetings and invite States and Organizations concerned to continue the discussion on improving in the cybersecurity ideas presented in this paper. With CANSO and IATA expressed their interest to contribute to this Agenda Item, the Secretariat will coordinate with interested parties to discuss various tasks under this Agenda Item.

CRV Post Implementation Issues in Bhutan

3.28 The ACSICG/9 meeting was informed about the issues faced by Bhutan related to CRV post implementation due to the non-readiness of peer States and the action taken by CRV OG and ACSICG including the two ad-hoc meetings for its resolution by WP/09. Bhutan and New Zealand further updated that due to some technical setup issues, Bhutan revised the SEP (System Engineering Plan) document, and the managed router service revision has been completed on 25th February, 2022. Bhutan now awaits for the technical setup from New Zealand. The acceptance and bidirectional test will be performed between the two countries after the completion of technical setup from New Zealand.

3.29 The ACSICG/9 meeting noted that Thailand has already implemented CRV and planned to test CRV circuits with Bhutan in June 2022. It was agreed that Bhutan and New Zealand would continue to work on above mentioned on-going proposal. The Ad-Hoc group will meet in last week of June 2022 to note the status of testing of CRV circuits between Bhutan and Thailand and progress on implementation of the temporary routing through New Zealand. Based on the status, the Ad-Hoc group will decide to continue the task to implement GRE tunnel between Bhutan and New Zealand or to close the action item.

3.30 Bhutan further informed the ICAO Office through email on 6th July 2022 that considering the connectivity between Bhutan and Thailand is currently under inspection process for reliability/stability test and after consensus with New Zealand, Bhutan has decided to discontinue the temporary CRV connectivity with New Zealand.

AMHS readiness status for supporting IWXXM Traffic of the States/Administrations - Sec (WP/06)

3.31 The ICAO Secretariat supplemented information for AMHS readiness status for supporting IWXXM Traffic. As part of Beijing Declaration on “commit to implementation by 2022: Common ground/ground telecommunication infrastructure to support ANS applications” with reporting indicators including the status of AMHS with File Transfer Body Parts (FTBP) function for IWXXM data, the ICAO APAC Region has been promoting the implementation of AMHS as a proper infrastructure identified for the Region to facilitate the exchange of IWXXM under **Conclusion APANPIRG/28/16** - Upgrade AMHS to support IWXXM traffic and **Conclusion CNS SG/22/4** (CRV OG/4/2) - ATN/BBIS States/Administration Use CRV for AFTN/AMHS Traffic.

3.32 The meeting noted that **13** States/Administrations provided their status on AMHS readiness for supporting IWXXM Traffic as in **Appendix C** to the Report, out of the **23** States/Administrations in the APAC Region which put their AMHS into operations per the AMHS Routing Directory Tables from the ATS Messaging Management Centre (AMC). Although there has been a significant increase in the AMHS readiness for supporting IWXXM Traffic, the reporting gap as well as the slow progress on the reporting were still identified, States/Administrations were urged to inform ICAO APAC Regional Office on their readiness and implementation progress/plan of AMHS with FTBP as soon as possible.

ATS Messaging Management Centre (AMC) Updating- Sec (WP/23)

3.33 This paper presented the State Letter Ref.: EUR/NAT 22-0239.TEC (NIA/SAN) dated 29 June 2022 regarding the *Management and update of Air Traffic Services (ATS) Message Handling System (AMHS) address and routing information*.

3.34 Since the introduction of global routing in AMC, there had been good participation from External COM Centres (i.e. States outside the ICAO EUR Region), and the AMC encouraged external COM Centres to continue to participate in the AMC operation. With the introduction of IWXXM, FTBP capabilities are of greater importance to the AFS. In this regard, all COM Centres were invited to update their FTBP capabilities information under the AMC Network Inventory section.

3.35 It was noted that some COM centres outside of the EUR Region have not uploaded the correct addressing tables in accordance with the AMC cycle. In this regard, it was recalled that the ICAO State Letter Ref.: AN 7/49.1-09/34 dated 14 April 2009 *Management and update of air traffic services (ATS) message handling system (AMHS) address information* should be re-iterated. As such, this paper reminded the action required regarding the Management and update of Air Traffic Services (ATS) Message Handling System (AMHS) address and routing information, including ensuring the international COM Centres in States are registered via <https://www.eurocontrol.int/tool/air-traffic-services-messaging-management-centre> as AMC users, and participate regularly in the AMC procedures for AMHS Address and Routing Management as outlined in the EUR ATS Messaging Management Manual (EUR Doc 021).

Outcomes of Webinar on CRV Implementation- Sec (IP/02)

3.36 The meeting reviewed the outcomes of the ICAO APAC Webinar on Implementation of CRV in APAC region, which was successfully conducted on **29th June 2022**. The Webinar was attended by **61** participants from **15** States/Administrations, and **1** telecommunication provider. Total **Five** (5) presentations were delivered by CRV experts from Fiji, Hong Kong China, New Zealand, Singapore, and the USA. During the Webinar, Questions and Answers (Q & A) sessions were held at end of each presentation through the Pigeonhole tool. Throughout the Webinar, a total of **47 questions**

were asked and more than 15 feedbacks for the Webinar were provided by Participants with **100% positive responses**. The webinar report, presentations, and other resources can be accessed by following link: <https://www.icao.int/APAC/Meetings/Pages/2022-CRV-Webinar.aspx>

Challenges Faced in Joining CRV– Sri Lanka (IP/19)

3.37 Sri Lanka presented challenges that AASL/Sri Lanka is facing in joining CRV. Sri Lanka informed that it planned CRV migration in a phased manner first with AMHS Singapore and the tests to be started tentatively in Nov 2022. Additionally, India is also migrating CRV very soon and AMHS Mumbai connection is planned to be replaced with CRV. AASL/Sri Lanka sought possible options on CRV migration with both AMHS Singapore and Mumbai, which are

Option 1:- Package D with 128kbps BW 64k for Singapore and 64k for Mumbai; and

Option 2:- Package D+ with 128kbps BW 64k for Singapore and 64k for Mumbai.

3.38 The meeting was informed that Option 1 is economically feasible. However, a single point of failure will result in total disconnection of AMHS/AFTN to both Sri Lanka and Maldives. Nonetheless, Option 2 will eliminate single point of failure, however the additional cost required to implement Package D+ is 8 times higher than the existing circuit cost of AMHS connection between Sri Lanka and Mumbai. This is with the present economic crisis in Sri Lanka where Sri Lanka Rupee has been depreciated against USD.

3.39 Sri Lanka shared that until such time the economy in Sri Lanka will be converged towards a positive growth rate, most probably until Dec 2023, AASL/Sri Lanka has a challenge to go for Option 2. It added that until such time, necessary negotiations are proposed to begin with India on following options.

Option A :- To retain with existing AMHS Mumbai/Colombo IPLC circuit

Option B :- To migrate CRV with AMHS Mumbai/Colombo under Package D at Sri Lanka end and keep the existing AMHS Mumbai/Colombo IPLC circuit as a contingency for CRV. In this case even in a CRV single point failure, both AMHS/AFTN communication between Mumbai and Singapore towards Sri Lanka and Male will be passed through the existing IPLC circuit.

Option C :- To migrate CRV with AMHS Mumbai/Colombo under Package D at Sri Lanka end and procure a low cost VPN connection between Mumbai and Sri Lanka as a contingency for CRV.

3.40 India shared its support to Sri Lanka and suggested Option C as the best option to implement.

3.41 The ICAO Secretariat informed the meeting that Package D+ is not a formal package approved in the current CRV common package and shared two definitions of Package D+ assumed by various States in the past few years. It was added that CRV OG Expert Ad-hoc group is working to formalize the Package D+ based on the definitions assumed by various States.

3.42 Sri Lanka informed that the Package D+ mentioned in the paper is actually two independent Package D. Therefore, the cost of Package D+ is two times of Package D. The ICAO Secretariat informed that based on Package D+ proposals shared by various Member States, two independent Package D have not considered as Package D+. The ICAO Secretariat will follow-up on this matter with PCCWG and Sri Lanka offline and provide all possible technical support to Sri Lanka for CRV Implementation. **ACTION ITEM 26-2**

Current Status of CRV Implementation in India (IP/22)

3.43 India shared the information on the latest progress of CRV implementation. The meeting noted that the Purchase Order for CRV implementation in India was awarded to M/s PCCWG

on 15th March, 2022. As per information received from M/s PCCWG the implementation of CRV network is getting delayed due to shortage of Semiconductor Chipsets required for Cisco Router. The latest delivery date given by M/s PCCWG is Dec, 2022 for CRV Implementation in India. India added that it has approached adjacent BBIS & BIS States to confirm their readiness for CRV connectivity with India, to avoid further delay in implementation. Consent from Thailand, Singapore, Sri Lanka, Bhutan, China & Nepal has already been received in this regard. Subsequently, LOA (Letter of Agreement) shall be signed with adjacent BBIS & BIS States for establishment of connectivity on CRV. India urged M/s PCCWG for meeting the timelines for establishing the CRV node at Mumbai, India and urged BBIS/BIS States having connectivity with India to keep themselves in readiness to avoid any further delay in establishing the connectivity.

Agenda Item 4: Information Management (IM)

Review Report of SWIM TF/6 - Sec (WP/07)

4.1 Dr. Amornrat Jirattigalachote, Strategic Planning Manager (Engineering), Policy and Strategy Management Bureau of AEROTHAI, Co-Chair of SWIM TF presented the report of the Sixth Meeting of the APAC SWIM Task Force (SWIM TF/6) held from 17 – 20 May 2022 via Video Tele-Conferencing (VTC). The meeting was attended by 213 participants from 18 States/Administrations, 5 International Organizations and 1 service provider. The papers and report of SWIM TF/6 meeting are available at: <https://www.icao.int/APAC/Meetings/Pages/2022-SWIM-TF6.aspx>

4.2 In the SWIM TF/6 meeting, MET Experts from Australia shared the concern of mentioning MET service providers as a non-aviation service providers or aviation support service providers. The SWIM TF/6 meeting requested CRV OG to deliberate the concern and finalize appropriate name for CRV users/subscribers other than ANSP.

Implications of the Revised Terms of Reference as a result of the CNS SG/25 Decision

4.3 The meeting noted the impact and implications of the change in the Terms of Reference (ToR) of the SWIM Task Force as a result of the decision by the CNS SG/25 meeting. The paper summarized the revisions on the SWIM Task Force ToR agreed by CNS SG/25, and explained the reasons and impacts for these changes in detail. The SWIM TF/6 meeting was informed that with revised ToR, the work of the APAC SWIM Task Force has been increased significantly. The SWIM TF will need to deliberate the impact of these changes on ongoing work. The SWIM TF/6 meeting was invited to review the current deliverables, how to deliver on the items stated in the new ToR, and consider how the task groups should be structured to produce the required deliverables.

Aviation Support Service Providers Joining CRV

4.4 PCCW introduced PCCWG Console Connect Aviation Platform for non-ANSP users to exchange SWIM data with CRV members. PCCWG informed that in order to provide an easy, managed, flexible and scalable mechanism for non-ANSP users to exchange SWIM data with CRV users, PCCW Global planned to extend its EMS node with its own developed software defined interconnection platform - Console Connect for Aviation and purposed built SWIM as Service Platform. Comparison among CRV, Console Connect Platform for Aviation, and Internet on Network Options, Information Security, Daily Support, and etc. were explained in the paper and it was added that Console Connect Platform provides web base user interface for SWIM application. Lastly, PCCWG informed that the SWIM services from ANSPs on CRV can be listed on PCCW SWIM Registry, where users can select, subscribe, and concluded that the Console Connect Platform provides an alternative path for non-ANSP users to exchange SWIM data with ANSPs who are on the CRV Network.

4.5 The SWIM TF/6 meeting discussed the certification standard and ability to support MET data of the PCCW Console Connect Aviation Platform, and was informed that the platform is in concept stage. The SWIM TF/6 meeting agreed that there is the need to deliberate in CRV OG the security impact of mixed operational environment, i.e. connecting more SWIM technical infrastructure service providers and users using internet/other network based services with CRV through a gateway.

Consideration of SWIM Architecture for Efficient Provision of MET Information Services - MET SG nominated experts

4.6 In 2021, the MET SG shared the concerns with regard to SWIM architecture for efficient and cost-effective provision of MET information services. Members of the MET community also raised concern on the accessibility of Meteorological Service Providers and airlines to CRV, SWIM services for less-sensitive MET data be accommodated in APAC SWIM technical infrastructure, and the cost implication of highly data intensive. It also discussed the needs of efficient MET information service provision to be supported by SWIM architecture.

4.7 Considering the operational needs of efficient MET information service provision mentioned above, a draft Conclusion titled *Activities to explore the use of the Internet for MET information services in Regional SWIM architecture* was proposed for SWIM TF/6 consideration. The SWIM TF/6 meeting noted that the MET information services have already been considered as a part of SWIM TF's work and regional SWIM architecture since its establishments and a specialised group has been created by CRV OG/9 that is devising terms and conditions along with standard operating procedures to join the CRV by other service providers than ANSPs such as MET and airlines.

4.8 According to the outcomes of discussions during SWIM TF/6 and APANPIRG procedural handbook dated 1 June 2020, the draft decision was endorsed by the meeting for CNS SG/26's adoption, which was adopted by CNS SG/26.

Decision CNS SG/26/04 (SWIM TF/06/01) - The Use of the Internet for MET Information Services in Regional SWIM architecture		
What:	That, the use of Internet for meteorological information services will be considered in designing the regional SWIM architecture.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why:	To support cost-effective and efficient meteorological information services for exchange of less-sensitive meteorological information in SWIM.	Follow-up: ☐ Required from States
When:	9-Sep-22	Status: Adopted by Subgroup
Who:	☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☒ Other: SWIM TF	

4.9 The CNS SG Chair commended the SWIM TF in timely managing the concerns from the MET SG and some APAC members.

4.10 The SWIM TF/6 meeting agreed that Task 2 group will include the use of Internet for meteorological information services in designing the regional SWIM architecture. The SWIM TF/6 meeting also discussed the need of participation of MET experts in SWIM TF and requested Member States to nominate MET experts to contribute and participate in various tasks of SWIM TF.

The Asia-Pacific SWIM Implementation Timeline - China, Japan, Singapore, and Thailand

4.11 The paper presented a proposal for a target timeframe for SWIM implementation in the Asia-Pacific Region. Considering a significant amount of work produced by SWIM TF so far, the meeting was suggested to consolidate all these works, experiences, and lessons learnt and to form an actionable implementation plan with a target timeframe for operational SWIM implementation in the Asia-Pacific region. Referencing to the timeframes of related events and publications, including the

publication of the ICAO PANS-Information Management (PANS-IM), which is expected to be published in 2024, and the sunset date of the current flight plan format (FPL2012) in 2032 being considered by ICAO ATMRPP, the paper proposed that the timeframe for SWIM implementation in the Asia-Pacific region to be set at between 2024 and 2030 with a buffer of 2 years before 2032 to conduct FF-ICE related operational trials prior to the planned sunset date for the FPL2012.

4.12 With aforementioned, the **Draft Conclusion SWIM TF/06/02: The Asia-Pacific SWIM Implementation Timeframe** was adopted by SWIM TF/6 for CNS SG/26 and APANPIRG/33 consideration, which was adopted by CNS SG/26.

4.13 The SWIM TF/6 meeting agreed that the scope of SWIM implementation depends on each State's strategies and the set of common information services, which States shall consider providing, needs to be agreed on by SWIM TF. The SWIM TF/6 meeting proposed that States may consider implementing SWIM technical infrastructure and participating in regional SWIM by developing their own or acquiring services provided by SWIM service provider. Moreover, States may consider implementing information service provision, information service consumption, or both, or subscribing to SWIM service provider to enable their information provision and/or consumption.

4.14 The other matter that may impact the SWIM implementation timeframe was the different schedules set out by the different ICAO Air Navigation Commission Technical Panels which were not aligned with each other was also discussed, including IWXXM dissemination date, the starting date of FF-ICE/R1 implementation, and publication date of the PANS-IM.

4.15 Considering to align all the timelines which will definitely assist States in planning their investment and transition, the meeting adopted the following Draft Decision for CNS SG/26 and APANPIRG/33 consideration, which was adopted by CNS SG/26.

Draft Decision CNS SG/26/05 (SWIM TF/06/03) - Harmonization of Timelines for SWIM-related Initiatives		
What:	To feedback to the ICAO Air Navigation Commission Technical Panels for a need to harmonize the implementation timelines of SWIM-related initiatives.	Expected impact: ☒ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why:	There exists different timelines for the implementation of SWIM-related initiatives identified by various ICAO ANC Technical Panels. This creates confusion within States on their corresponding implementation sequences and as to how these different timelines are to be met.	Follow-up: ☐ Required from States
When:	9-Sep-22	Status: Draft to be adopted by PIRG
Who:	☒ Sub groups ☐ APAC States ☒ ICAO APAC RO ☒ ICAO HQ ☒ Other: SWIM TF	

SWIM Implementation and the Asia-Pacific Seamless ANS Plan - China, Japan, Singapore, and Thailand

4.16 The paper examined the relationship between SWIM implementation in Asia/Pacific and the Asia/Pacific Seamless ANS Plan. In the current edition of the Asia/Pacific Seamless ANS Plan, version 3.0, published in November 2019, SWIM is only mentioned once in Appendix C Seamless ANS

Principles under the Technology and Information section, Aeronautical Data sub-section stating about the cooperative development of SWIM to support interoperable operations. As SWIM is a key piece of infrastructure required to support other initiatives currently included in the Plan and the future operational concept, it was proposed that CNS SG and SWIM TF consider including SWIM implementation as part of Performance Improvement Plan in the next edition the Asia/Pacific Seamless ANS Plan aligned with SWIM implementation timeframe.

4.17 With aforementioned, the Draft Conclusion SWIM TF/06/04: *Inclusion of the Asia/Pacific SWIM Implementation in the Asia/Pacific Seamless ANS Plan* was adopted by SWIM TF/6 for CNS SG/26 and APANPIRG/33 consideration, which was adopted by CNS SG/26.

4.18 The two proposed **Draft Conclusions SWIM TF/06/02: The Asia-Pacific SWIM Implementation Timeframe** and **Draft Conclusion SWIM TF/06/04: Inclusion of the Asia/Pacific SWIM Implementation in the Asia/Pacific Seamless ANS Plan**, adopted by CNS SG/26 was merged as the following one draft conclusion based on the recommendations of CNS SG Chair for APANPIRG/33 consideration.

Draft Conclusion CNS SG/26/06 (SWIM TF/06/02, SWIM TF/06/04) - The Asia-Pacific SWIM Implementation Timeframe and inclusion of the Asia/Pacific SWIM Implementation in the Asia/Pacific Seamless ANS Plan		
What:	To set the timeframe for the implementation of SWIM in the Asia-Pacific region to be between 2024 and 2030, with 2030 being the target timeline for implementation completion. CNS SG and SWIM TF to consider including SWIM implementation in the next edition of the Asia/Pacific Seamless ANS Plan.	Expected impact: ☐ Political / Global ☐ Inter-regional ☒ Economic ☐ Environmental ☒ Ops/Technical
Why:	This is to set the concrete target implementation of the Asia-Pacific regional SWIM to assist States in harmonizing their implementation plans in order to achieve the seamless information exchange across the region in time for future operations, e.g. FF-ICE. Additionally, to ensure that SWIM, a key building block to achieve the vision outlined in ICAO Doc 9854 Global ATM Operational Concept (GATMOC), is captured in the Asia/Pacific Seamless ANS Plan, providing an overall framework for Asia/Pacific States to plan their implementations to meet the future performance requirements.	Follow-up: ☒ Required from States
When:	9-Sep-22	Status: Draft to be adopted by PIRG
Who:	☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☒ Other: SWIM TF	

4.19 Considering that APAC SWIM Timeline is proposed to be started from 2024 and to incorporate into the Seamless ANS Plan v5.0, which will be published in 2025, the SWIM TF/6 meeting agreed to add **SWIM-B2/1- Information Service Provision** and **SWIM-B2/2- Information Service Consumption** under **Priority Two** in the Seamless ANS Plan v4.0 to be published in 2022. The content to be added in the plan was discussed, prepared, and finalized, which is provided in **Appendix D** to this report.

Result of Asia/Pacific SWIM Implementation Plan and Status Survey- Task 1 Leads

4.20 The paper presented the results of the ICAO Asia/Pacific SWIM Implementation Plan and Status survey conducted between March and April 2022. Based on the survey results obtained, recommendations are provided for the consideration of SWIM TF/6.

4.21 Following the **Conclusion CNS SG/25/03**, the ICAO Asia/Pacific SWIM Implementation Plan and Status Survey was prepared by China, Japan, Singapore, and Thailand in consultation with Task leads under SWIM TF, and later disseminated to all Asia/Pacific States/Administrations by State Letter on 1 March 2022. Throughout March and April 2022, 49 responses in total were received from 26 States/Administrations, including Australia, Bhutan, Cambodia, China, Fiji, France, Hong Kong China, India, Indonesia, Japan, Lao PDR, Macau China, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Papua New Guinea, Republic of Korea, Sri Lanka, Singapore, Thailand, USA, and Vietnam. The majority of the responses was from civil aviation regulators, AIS/AIM providers, ANSPs or ATM service providers, and MET service providers. Only one response was from airport operator, while none was obtained from airspace user.

4.22 The paper elaborated on the survey results received from States and based on the survey results obtained, the paper also provided some recommendations, which included

- 1) Timeframe for completion date/expected completion date of the three SWIM key components, which was identified to be between 2022 and 2030, can be in lined with the proposal stated in SWIM TF/6 WP/07.
- 2) With the list of common SWIM information services and SWIM-enabled applications indicated in the majority of the responses, it is suggested to adopt a phased approach in the Asia/Pacific SWIM implementation roadmap to be further devised, to ensure the harmonized implementation of this common list among stakeholders, in turn leading to the region-wide operational benefits.
- 3) Based on the feedback received and considering a significant amount of work done by SWIM TF so far, SWIM TF is recommended to consider consolidating (i) the Asia/Pacific SWIM Concept of Operations and (ii) the Asia/Pacific regional SWIM Implementation Guidance documents to assist States/Administration/Organizations in their SWIM planning and implementation. Moreover, in the case where the inclusion of SWIM in the new version of the Asia/Pacific Seamless ANS Plan, as proposed in SWIM TF/6 WP/08, is adopted by APANPIRG, these two documents can then be used as supplements to the Asia/Pacific Seamless ANS Plan in the future.

4.23 The SWIM TF/6 meeting noted that Recommendation-1 was already agreed by the **Draft Decision SWIM TF/06/03** of WP/07. Recommendation-2 can be added in the Task 1 once detailed SWIM Roadmap is prepared. Recommendation-3 was discussed in WP/21 of SWIM TF/6. Task 1 will consider phased approach and a common set of SWIM information services while developing APAC SWIM Implementation Roadmap.

Proposal to establish a Joint Work Group between the ATM SG and CNS SG to Create the FF-ICE Implementation Strategy

4.24 Task 9 leads reviewed the report of the Second Meeting of the Information Management Panel (IMP/2) held virtually from September 27 to October 1, 2021, and the status of the Air Traffic Management Requirements and Performance Panel (ATMRPP), which is developing SARPs and Guidance Materials to implement FF-ICE operations under the SWIM environment. The meeting was informed that the IMP/2 reviewed the latest draft Procedures for Air Navigation Services –Information Management (PANS-IM) and accepted all the modifications. Furthermore, the applicability of the proposed information security framework, maintenance of the information security provisions, and the mandatory use of specific IPv6 addresses (aviation block) and domain names were also discussed in the IMP/2 meeting. The meeting also reviewed the latest version of SWIM Manual

Volume II – Implementation Guidance, and the first edition of the Guidance Material - Manual on SWIM Implementation has been ready for publication. The IMP/2 meeting reviewed the ATM Information Reference Model (AIRM), endorsed the release of the AIRM v1.0.0, and supported the AIRM work/release plan.

4.25 Additionally, the meeting was informed that ATMRPP has completed most of the work on FF-ICE/R1 focusing on pre-departure phase Trajectory Negotiation with ATMRPP/4, and the focus has shifted to post-departure phase, FF-ICE Release 2 (FF-ICE/R2) and noted that plans to draft the provisions on FF-ICE/R2 by 2028 are being considered in the ATMRPP.

4.26 Considering the FF-ICE implementation is not something that can be completed by the SWIM TF alone and collaboration with other groups such as ATM and CNS is important, the SWIM TF/6 meeting formulated and adopted the **Draft Decision SWIM TF/06/05- Establish a Joint Work Group between the ATM SG and CNS SG to Create the FF-ICE Implementation Strategy** for CNS SG/26 and APANPIRG consideration.

4.27 The meeting deliberated at length the rationale and appropriate timing on the proposal of establishing a joint working group. The CNS SG Chair expressed his appreciation to the initiatives taken by the SWIM TF and shared his views, after consulting the views from the ATM SG Chair, that we should be prudent and with very strong justifications in establishing new contributory bodies under the APANPIRG. It is important for the meeting to consider how best we could make use of the existing contributory bodies. There has been established scheme in formation of new contributory bodies which the Sub-groups have followed over the years to handle prioritized ASBU modules. However, the meeting was also informed that the implementation of FF-ICE by its nature requires a strong and close coordination and cooperation between operational and technical experts where there may not be any single existing contributory body owning such a multi-disciplinary specialists to tackle the issue.

4.28 The meeting was informed that the Third Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (ATMAS TF/3) held from 7 – 10 June 2022 had proposed to set up a half-day seminar to discuss the topics of interest identified by most Member States, including FF-ICE, SWIM, system interoperability, etc. In this regard, the ATMAS TF may organise the seminar on FF-ICE in the APAC region in 2023. The meeting was also reminded that the FF-ICE presentation and small demonstration were conducted during the ICAO APAC SWIM Workshop held from 6-7 July 2021. However, considering the existing different levels of understanding on FF-ICE among the APAC States/Administrations, the meeting suggested that the said seminar could be a starting point and relevant outcomes/recommendations may further be considered to bring the matter forward. Additionally, the meeting considered that it might be pre-mature to decide the said proposal and that a dedicated TF/WG may be considered in the future when such need has been fully deliberated by all relevant stakeholders during the seminar to be held by the ATMAS TF. The meeting requested the ICAO Secretariat to ensure that SWIM TF and ACSICG experts are involved in the FF-ICE workshop/webinar/seminar to be held by ATMAS TF. **ACTION ITEM 26-3**

4.29 The SWIM TF/6 meeting noted that similar activity of formation of a joint group is being carried out by the Inter-Panel task force consisting of ATMRPP, IMP, and CP members to ensure the consistency among ICAO provisions related to FF-ICE.

Review of SWIM TF ToR and SWIM TF Work Plan

4.30 The SWIM TF/5 meeting revised the ToR of SWIM TF considering the progress made since the establishment of SWIM TF, the update of ICAO global and regional air navigation plans, and the revised task groups adopted at SWIM TF/4, and endorsed Draft Decision SWIM TF/05/02- *Revised SWIM TF ToR* for adoption by CNS SG/25, which was further adopted by CNS SG/25 by **Decision CNS SG/25/04**.

4.31 The CNS SG/25 recapped the concern shared by Australia for SWIM TF ToR and reminded the SWIM TF to consider other IP-based network technologies in their forthcoming review on ToR. The CNS SG also advised the SWIM TF to consider other modifications proposed by APAC

member(s) in their task-lead meetings in 2021 and SWIM TF/6 could present revised ToR to the CNS SG/26. The meeting suggested and Australia had agreed to nominate SWIM experts to participate in SWIM task leads and task force meetings.

4.32 APANPIRG/32 adopted the Decision APANPIRG/32/12: *Meteorological expert contribution to SWIM/TF* based on Draft Decision MET SG/25-08. The ICAO Secretariat shared the State Letter Ref.: T 4/3.2.9 - AP070/22 (MET) dated 9 May 2022 on subject: *Decision APANPIRG/32/12: Meteorological expert contribution to SWIM/TF* to encourage MET representatives of Member States to participate in the SWIM TF.

4.33 As an established effective practice in progressing various tasks of the SWIM TF, online Task Leads (TLs) coordination meetings have been organized from time to time between Task Force meetings. The latest TLs coordination meeting (video teleconference) was held on 01 September 2022. Based on the detailed deliberations, the SWIM TF ToR has been modified. Considering the progress made since the SWIM TF/5 to deliberate the concerns raised in CNS SG/25 and MET SG/25, SWIM TF's Terms of Reference (ToR) amended in SWIM TF Task Leads meetings was presented to the meeting for further review. The meeting reviewed and updated the draft ToR and endorsed following draft decision for CNS SG/26 adoption, which was adopted by CNS SG/26.

Decision CNS SG/26/07 (SWIM TF/06/05) – Revised SWIM TF Terms of Reference			
What: That, the revised SWIM TF Terms of Reference (ToR) as shown in Appendix E be adopted.		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: To align with the progress made since the SWIM TF/5 and outcomes of Action item 25-1 from CNS SG/25.		Follow-up:	☐ Required from States
When:	09 September 2022	Status:	Adopted by
Who:		Subgroup	
Who: ☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ			
☒ Other: SWIM TF			

4.34 To ensure that the objectives set in the ToR can be achieved, the Statement of Work (SOW) of each Tasks was already updated in SWIM TF/5 meeting. The SOW will be reviewed in further Task Leads Meeting to be in consistent with revised SWIM TF ToR. The SWIM TF/6 meeting also reviewed and updated the SWIM TF Work Plan.

Review Outcomes from MET SG/26- Sec (WP/34)

4.35 The paper presented outcomes from MET SG/26 relevant to the CNS SG, including discussion on SWIM architecture support for MET information, MET experts' contribution and participation in the SWIM TF, and CNS-related documenting of MET service providers as “non-aviation” service providers. The paper invited the Meeting to adopt the proposals by the SWIM TF and MET SG, which support the cost-effective and efficient exchange of MET information in SWIM.

4.36 The Twenty-Sixth Meeting of the Meteorology Sub-group (MET SG/26), held online from 1 to 5 August 2022, reviewed the progress of the MET SG's work plan and considered further actions to facilitate the States' planning and implementation of the ICAO provisions related to meteorological (MET) service. MET SG/26 recalled that because the CRV might not provide a cost-effective and efficient solution needed for the exchange of all required MET information in the SWIM environment, MET SG/25 had previously adopted and presented to APANPIRG/32 the Draft Conclusion MET SG/25-07 which was not formally adopted as an APANPIRG Conclusion.

4.37 Nevertheless, APANPIRG/32 did acknowledge that the SWIM TF would take action as proposed in Draft Conclusion MET SG/25-07. i.e., “the MET SG’s draft conclusion will be captured in the ongoing review of SWIM/TF terms of reference”. MET SG/26 noted that the Sixth Meeting of the SWIM Task Force (SWIM TF/6) discussed concerns raised by the members of MET SG about SWIM architecture for the efficient and cost-effective provision of MET information services through WP19 and formed a Draft Decision SWIM TF/06/01 – *The Use of the Internet for MET Information Services in Regional SWIM architecture* and Draft Decision SWIM TF/06/06 – *Revised SWIM TF Terms of Reference* to include “other IP-based networks” in the APAC Regional SWIM architecture.

4.38 MET SG/26 welcomed the SWIM TF’s request to the Member States to nominate MET experts to contribute and participate in various tasks of the SWIM TF. The involvement of MET experts in the activities of the SWIM TF could help overcome some prevailing concerns or misunderstandings on how MET information will be made available and used in a SWIM environment. MET SG/26 noted that, given some States’ concerns about documenting MET service providers as “non-aviation” service providers, SWIM TF/6 had requested the CRV Operations Group (CRV OG) to finalize an appropriate name for CRV users and subscribers other than ANSPs.

4.39 MET SG/26 requested CNS SG/26 to note the importance of adopting the proposals in Draft Decision SWIM TF/06/01 and Draft Decision SWIM TF/06/06, which reflect the action previously proposed in Draft Conclusion MET SG/25-07, supporting the cost-effective and efficient exchange of MET information in SWIM.

Status of Proof of Concept Based SWIM Project for Exchanging Aeronautical, Flight and Weather Data- India (IP/21)

4.40 India presented the Status and accomplishments of the Proof- of- Concept (POC) based SWIM project undertaken by India. India informed that the project scope covered building SWIM Technical infrastructure, generating digital datasets for Digital NOTAM, OPMET & flight related ATS messages. At present SWIM Services, SWIM Digital Applications, and, most notably, SWIM Gateway services with AMHS and AFTN Switch have been developed and in-house testing has been carried out successfully.

4.41 India shared capabilities of the prototype SWIM System, SWIM Infrastructure Developed for POC based SWM system, and SWIM technical infrastructure. It was added that the project is in the final stage and the system has been tested with Aero Thai SWIM system for validating the capabilities and deliverables. Through this integration activity, AAI and Aero Thai exchanged Flight Plan Data (FPL, DEP & ARR) in FIXM v 4.2 format, Digital NOTAM data (NOTAM - New, Replace, Cancel) in AIXM v 5.1.1 format, and Meteorological data (METAR, SIGMET) in IWXXM v 3.0 format over SWIM channel using AMQP 1.0 protocol. A successful integration has validated that

- 1) System complies with ICAO SWIM Standards
- 2) Capability to integrate with 3rd party systems amid the technological and implementation differences between the different systems

4.42 The meeting was informed that the successful completion of the project shall pave the way for preparing Roadmap for the SWIM implementation in AAI. India encouraged other States to interface their SWIM system with Indian POC SWIM system for further testing and validation.

4.43 The meeting appreciated the information sharing from India and encouraged other States to contact AAI to interface their SWIM system with Indian POC SWIM system.

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

Review Report of SRWG/6 - Sec (WP/08)

5.1 The paper presented the report of the Sixth Meeting of the Spectrum Review Working Group (SRWG/6) of APANPIRG, held via VTC from 1 to 3 March 2022. The meeting was attended by 74 participants from 16 States/Administrations and 2 International Organizations.

Outcome of APG23-3 Meeting

5.2 The meeting reviewed the outcome of the Third Meeting of Asia Pacific Telecommunity (APT) Conference Preparatory Group for World Radiocommunication Conference 2023 (APG23-3) held on 8 – 13 November 2021. Regional Officers CNS presented Information Document APG23-3/INF-15 on the ICAO Position for WRC-23, i.e. the result of study progressed by Frequency Spectrum Management Panel (FSMP) based on the International Telecommunication Union (ITU) studies, in order to monitor progress and status of APAC regional preliminary views for WRC-23 to protect aeronautical spectrum, ensure ICAO Position was supported in accordance with APANPIRG/27 Conclusion 27/45 and to report to CNS SG and its contributory bodies on the regional preparation progress made by APG. The meeting was invited to note the outcome of APG23-3, including agenda items where aviation is seeking actions by WRC.

VHF COM Simulation for 2030

5.3 The meeting reviewed the latest development in simulating the VHF COM requirements for APAC in 2030 as deemed necessary for the simulation for 2030. SRWG/5 prepared the survey for *Submission of Frequency Requirements for the Period 2021 – 2030*, and circulated to Member States through State Letter *Simulation of VHF COM Frequency requirements for next 10 years* on 09 April 2021. The ICAO APAC Office has received submissions from eight States/Administrations. CNS SG/25 urged delegates to take necessary action to respond to the State Letter by providing required information for simulation as early as possible. Preliminary analysis on the States' submission revealed the challenge of uncertainty to determine the medium-term spectrum requirements for VHF communication services. Further analysis is being conducted with concerned States to determine whether these requirements can be assigned. States/Administrations were invited to review and provide up-to-date information for Frequency List 3 by using Frequency Finder as the simulation result would only be meaningful for sufficient frequency data. States/Administrations were invited to report issues to the Secretariat team during this interactive process.

Frequency Simulation for India

5.4 The meeting presented the outcome of frequency simulation for India per discussion in SRWG/5 WP/07 for future assignment. The simulation demonstrated that the frequency requirements requested by India for up to 2030 can be satisfied within the frequency band 117.975 - 137 MHz with conditions, including a re-organization for the pools to which frequencies are allotted. In addition, heavy congestion is expected at that time throughout most of this frequency band. As such, a similar analysis in 3 - 5 years 2022 was recommended to assess the severity of the congestion. This study set an example on the frequency planning techniques with actual situation to estimate the future traffic growth and subsequently the need for an increase in frequency channels. From the study result, in case 8.33kHz channel spacing were identified as necessary, strategic planning similar to that of Europe could be adopted. The meeting noted the discussion on more flexible use of the VHF COM Frequency Allotment Plan. Two relevant Action Items were proposed in SRWG/6 and endorsed in the meeting as follows:

- Review the registered frequencies from the simulation conducted in 2016 in the Frequency Finder, and remove those temporary frequencies in the Frequency Finder in the previous simulation service; and

- Establish an ad-hoc group to review the VHF COM Frequency Allotment Plan for APAC in terms of effective use of frequencies in the region, including the review of non-safety critical frequency use.

Preparation for Implementation of VHF Com 8.33 kHz Channel Spacing Requirements in APAC Region by Indonesia

5.5 This paper discussed Indonesia's preparations for the implementation of VHF COM 8.33 kHz channel spacing. Indonesia stated that the implementation directly impacts the ANSP, airline operators, ground service (e.g., ground handling, VHF data link frequencies), heliport operators as main users of such frequency. To ensure all registered civil aircraft operating in Indonesia are capable of operating at 8.33 kHz, Indonesia will conduct a further survey. When 8.33 kHz channel spacing implemented, some issues were identified as follows:

- Operational use will have an impact on the ATC load (phraseology) when using the 3 decimal place;
- Implementation of 8.33 kHz channel spacing will impact ANSP on replacing all the VHF COM facilities which incapable of working on that channel space;
- It is necessary to consider the impact on airlines; and
- Need to update national regulation of the use of 8.33 kHz if it has been recommended by ICAO APAC in future.

5.6 The paper provided adequate information and precise presentation as a good observation on the subject of implementation of 8.33kHz channel spacing in the Region. The meeting suggested considering formulating an implementation roadmap along with deliberation with individual States when the matter matures in future. IATA acknowledged that most of airline air transport fleet are already equipped with 8.33 kHz VHF Voice Channel Spacing. IATA suggested that the APAC region to plan ahead and establish an agreement for a structured implementation plan and timeline for eventual migration to 8.33 kHz, including an accommodation strategy for non-complying aircraft.

Aeronautical Frequency Spectrum Coordination and Planning Criteria in the APAC Region

5.7 The meeting reviewed the current practices and coordination procedures for aeronautical facilities and services operating in the aeronautical frequency bands and the evolution of planning criteria employed. States should coordinate for all frequency assignments that may affect the use of frequencies in other States. States should coordinate in principle with the Regional Office for all frequency assignments that may affect the use of frequency assignments coordinated through the ICAO mechanism. Not doing so will ultimately result in unforeseen interference, less efficient and less flexible assignment coordination and planning in a congested environment, as there will not be any possibility of optimizing assignments to solve congestion, as well as for a chance to conduct a meaningful simulation at the regional level. As such, the following Draft Conclusion was proposed and discussed in CNS SG/26. The Secretariat raised that use of frequencies belongs to States themselves and thus need to encourage States to coordinate with ICAO office to avoid possible interference. With consideration that frequencies should be coordinated before deployment by default to avoid undesirable interference, the Chair suggested the Secretariat to issue a State Letter for promulgating the Draft Conclusion SRWG/6/1. **ACTION ITEM 26-4.**

5.8 The meeting discussed the frequency planning principles adopted by the ASIA/PAC/3 RAN Meeting in 1993 which covered NDB (List 1), VOR, DME and ILS (List 2), VHF COM (List 3). The latest revisions of the Handbook on Radio Frequency Spectrum Requirement for Civil Aviation (Doc 9718) Volumes I and II have been approved by the Secretary-General and published in early 2022. Subsequently, the revised planning criteria contained in the revision for compatibility assessment of frequency assignments to VHF COM systems and NAV systems (ILS, VOR, DME and GBAS/VDB) have been incorporated in the new release of the Frequency Finder tool. With the Doc 9718 overrides previous RAN meeting outcome, the following Draft Conclusion was discussed and endorsed by CNS SG/26 for further consideration in APANPIRG/33:

Draft Conclusion CNS SG/26/08 (SRWG/6/2) - Planning Principle for Aeronautical Frequency Bands of 108-117.975 MHz, 960- 1215 MHz and 117.975- 137 MHz		
What: That, Doc 9718, Handbook on Radio Frequency Spectrum Requirements for Civil Aviation, Volume II, Second Edition – 2022, is adopted as the planning principle for aeronautical facilities and services operating in the aeronautical frequency bands of 108-117.975 MHz, 960- 1215 MHz and 117.975- 137 MHz in APAC.		Expected impact: ☐ Political / Global ☒ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To implement the updated ICAO provisions	Follow-up:	☐ Required from States
When: 25-Nov-22	Status:	Draft to be adopted by PIRG
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other: -		

Outcome of Ad-Hoc Group Activities on 50 kHz Channel Spacing for VOR/ILS Operations

5.9 This paper summarized the outcome of the Ad-hoc Group activities with regard to the implementation of 50 kHz channel spacing in the frequency band 108.000-117.975 MHz for VOR/ILS operation in the APAC region. The ad-hoc group proposed a questionnaire for discussion in SRWG/6. The challenges identified of implementing 50 kHz channel spacing are deemed primarily with airspace users (airline operators) and not with ground segment. The need for active coordination between the stakeholders including ANSPs, Civil/Military and Airline Operators (IATA) was also highlighted. The ad-hoc meeting also noted that the ICAO Frequency Finder tool fully supports 50 kHz channel spacing. The status of coordination within India and consultation with all stakeholders including IATA and its Military Organizations was presented. The stakeholders have consented to implement 50 kHz channel spacing within India. To speed up the process, the Secretariat published a questionnaire via ICAO APAC State Letter Ref.: AP068/22 (CNS) dated 28 April 2022.

Minimum Coordination Distance and the Need for Coordination of Frequency Assignments

5.10 This paper described the principles to observe and calculate with examples when establishing a minimum coordination distance between VHF COM and NAV facilities. Beyond this distance, no frequency coordination is required with respect to the desired facility. In aeronautical frequency assignment planning, the receiving station is typically operating at the edge of the Designated Operational Coverage (DOC) at the maximum range and height. It is not feasible to establish a single value for a minimum coordination distance because of the variables to be considered in the relevant calculations, States are invited to note that all facilities that do not meet this requirement need to be coordinated with ICAO. Besides, it is important to coordinate the use of frequency in order to avoid interference with other States, however, a State should be allowed to determine, based on ITU standards, other technical standards and geographical terrain whether the minimum coordination distance requirements are met. The Regional Guidance Material being developed will deliberately address this issue clearly.

Rationale for Placing Proper Frequency Coordination Mechanism and Framing Guidelines

5.11 India reviewed the need for placing a proper coordination mechanism and framing explicit policy guidelines for States. India informed that all their new frequency assignments have been coordinated with ICAO Regional Office before being used in order to protect the frequencies being used in India and neighbouring countries from harmful interference. However, they noted that the ICAO frequency lists do not contain the complete assignments and the assignments from many States are not fully recorded in the relevant lists. The issue was discussed during the online Ad-hoc Committee

Meeting on 8, Feb 2022, with certain points as highlighted hereunder need to be addressed to give a comprehensive guidance to States:

- Clarity is required with respect to the RAN meeting conclusions and relevant Annex 10 Volume V provisions, in respect of whether the States are required to coordinate and record all the new assignments with the Regional Office or only those assignments near the border areas.
- In case the new assignments contemplated near the border areas are to be coordinated, what are the specific distances required for different services for which coordination is necessary.
- Whether the military assignments (all or near the borders) are required to be coordinated. Normally, classified assignments are not disclosed. India presently is coordinating quite a number of military assignments.
- The coordination practices followed by the States/Administrations of other Regions may help to replicate in Asia/Pac region.
- Need for framing explicit guidelines to remove the ambiguity and for compliance by States may be considered.

Implementation of 50 kHz Channel Spacing in China

5.12 China shared their implementation of 50 kHz channel spacing due to shortfall from actual demand from the rapid development of the civil aviation industry and the substantial increase in the number of Radio Navigation Stations (RNS). Since October 1st, 2014, all new / relocated LOCs, GPs, VORs and DMEs shall meet the followings:

- The tunable frequency spacing of LOC and VOR equipment shall at least reach 50 kHz;
- The tunable frequency spacing of GP equipment shall at least reach 150 kHz; and
- Both X and Y channel modes are applicable for the DME equipment.

To ensure safe operation, CAAC adopts the mixing condition between 50 kHz and 100 kHz channel spacing when setting the protection distance of RNS, and refers to Annex 10, Attachment C to Volume I, paragraphs 2.6, 3.4 and 3.5 for specific details. Implementation of 50 kHz channel spacing is progressing steadily. Japan has also reported their implementation of 50kHz channel spacing for VOR and LOC, as well as X and Y channels for DME.

Latest Updates to Frequency Finder Tool

5.13 The latest work, enhancements and functionalities brought to the Frequency Finder tool were discussed to assist ICAO Regional Offices and States to manage and coordinate aeronautical frequency assignments in ICAO COM Lists 2 and 3 as well as SSR Mode S II/SI codes. Frequency Finder provides the calculation of interference areas and a geographical interface for plotting of the frequency assignments, including any interference area. Work on the development of a module for VHF/UHF navigation systems as in COM list 2 (ILS, VOR, DME and GBAS) has been completed using the frequency assignment planning criteria as per the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation (Doc. 9718) Volume II approved in 2021. Two enhanced features were introduced, including plotting interference contours in the VHF-NAV module on the Google Map, and a global database for Mode S II/SI code assignments. The meeting was invited to make extensive usage of the Frequency finder tool for frequency coordination and provide feedback on FF tool usage, suggestions, bugs and recommendations. The meeting was also briefed on the development of online course on fundamentals of frequency management.

Draft of Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material

5.14 The meeting discussed and reviewed the second edition of the draft of Asia Pacific Regional Aeronautical Radio Frequency Management Guidance Material. The guidance includes objective, scope, institutional framework, spectrum management and procedure of APAC region, air-

ground communication and radio navigation aid frequency management information. Following issues for meetings' attention and discussion:

- The minimum coordination distance for radio navigation facilities;
- The minimum separation distance for Localizer and Glide Path;
- The minimum separation distance for adjacent channel of Localizer and VOR;
- Influence of Aircraft Contribution Factor on the Calculation of GBAS Protection Ratio;
- Criteria for Identification coordination.

The meeting reviewed the guidance material for further improvement. To further proceed with the draft, the Secretariat will issue a State Letter to invite the APAC States to review and comment on the draft guidance document after further completion of the draft.

Potential Impacts from 5G Implementation on Aircraft Radio Altimeters – Outcomes in Relevant Meetings and Regional Updates

5.15 This paper reviewed the discussion in APAC after SRWG/5 about 5G implementation and potential impacts on aircraft radio altimeters, and relevant regional updates including:

- ICAO Headquarters State letter dated 25 March 2021;
- Outcomes of 12th Meeting of Frequency Spectrum Management Panel Working Group (FSMP WG/12);
- Outcomes of SRWG/5 and CNS SG/25;
- Outcomes of RASG-APAC/11 and **Conclusion RASG-APAC 11/3** and **Decision RASG-APAC 11/6** regarding *Potential Interference to Aircraft Radio Altimeter by 5G Telecommunications System*
- Regional and global developments on the issue, including FAA, ASEAN, GSMA and APT statements/researches/reports

As agreed in CNS SG/25, Member States would monitor the impact of 5G on radio altimeters in their States/Administration about the safety and frequency spectrum issues. Member States CAA and airworthiness office may collect all relevant information and past issues reported, if any, and inform RASG-APAC of any significant concern. The issues related to frequency spectrum may be brought to the attention of the CNS section of the ICAO APAC Office for further coordination with RASG-APAC and ICAO Headquarters.

5G Interference to Aircraft Radio Altimeters – IATA and Thailand

5.16 The paper discussed recent lessons learned concerning the deployment of 5G telecommunication networks and outlines recommendations to mitigate the potential risks to flight safety by 5G deployments. It also reviewed risk mitigation strategies and next steps for implementation. As a minimum, actions and regulatory measures need to be taken and put in place to safeguard the use of radio altimeters. Examples from States cooperated 5G network providers about the provision of location information for their stations, as well as details of the transmission characteristics required. It cited that maintaining current safety levels for aircraft, passengers and flight crews must be of highest priority. States should ensure that every frequency allocation/assignment is comprehensively studied and is well proven not to adversely impact aviation safety and efficiency, and States must provide the necessary leadership and act as a fair facilitator to ensure open and positive information sharing between the two industries and national aviation and telecommunication regulators.

5.17 As such, the meeting was invited to review and acknowledge the safety concerns and potential operational impacts of 5G telecommunication system deployment to radio altimeter, to consider incorporating "C-Band mobile telecommunications interference impact on aviation operations" into the ToR of the SRWG, to request ICAO APAC office to consider issuing a State letter to States within the Asia/Pacific Region in a similar manner to the NACC letter; and to consider adopting actions taken by some States to mitigate 5G interference and suggest additional actions as necessary and appropriate. This paper also requested ANSPs and aviation safety regulators to brief relevant government and telecommunication regulatory/management agencies about the potential

impact of 5G deployment on aviation safety, and propose necessary provisions for the spectrum auctioning/allotting process that will ensure the radio altimeter frequency is free from harmful interference at and around airports.

5.18 To address these proposals, the Secretariat introduced the original ToR of SRWG on studying necessary work for introducing 8.33kHz channel spacing and later included the topic of frequency spectrum planning. Due to the cross-domain and multi-facet nature of the issue involving frequency spectrum and flight safety, the ICAO recommended that the terms of reference of SRWG remain unchanged but the concern raised in this paper could be addressed through a dedicated Agenda Item for discussion in future meetings as the need arises. The meeting noted that ICAO HQ is preparing a State Letter or Electronic bulletin to be issued in 2022, hence APAC Region would not need to issue its own State Letter on the same subject. The Secretariat invited IATA to review and make improvements to existing Action Item to adequately address the concerned raised, and APAC States were informed to *take necessary follow-up action at the regional level, to support CAAs working with State's spectrum regulators to avoid future safety issues on radio altimeter due to 5G implementation.*

5.19 Considering the two RASG-APAC/11 Conclusion/Decision, i.e. **Conclusion RASG-APAC 11/3** and **Decision RASG-APAC 11/6** regarding *Potential Interference to Aircraft Radio Altimeter by 5G Telecommunications System* have already covered the scope of intended proposal, it would be a duplication of effort should the same issue be under APANPIRG that have already been addressed under RASG-APAC. The meeting was further informed that the has been communicated and brought for attention to the ITU Regional Radiocommunication Seminar 2020 for Asia & Pacific held on 28 October 2020, as well as to the Twenty-Sixth Meeting of the Regional Interagency Working Group (IAWG) on Information and Communication Technology (ICT) held on 17 January 2022. The Secretariat reminded that States/Administrations and industry to provide feedback to RASG-APAC and APANPIRG, and its sub-groups, on reports of interference from 5G networks as detailed in Decision RASG-APAC/11/6.

Radio Altimeters and 5G Administration C-Band Deployment – United States

5.20 The flimsy reviewed the synopsis, intra-agency and industry coordination on the 5G deployment, and actions taken by Federal Aviation Administration (FAA) via Airworthiness Notices (AD), Alternative Methods of Compliance (AMOC) and NOTAMs. The FAA expressed that they believe the expansion of 5G C-band and aviation will safely co-exist. The FAA continues to work closely with the Federal Communications Commission (FCC) and wireless companies, and they are making progress toward safely implementing the 5G C-band expansion. They are confident with the ongoing collaboration we will reach this shared goal. The flimsy introduced relevant ADs issued, as well as the AMOC process which allows anyone to propose to the FAA an alternative method of compliance or a change in the compliance time, if the proposal provides an acceptable level of safety. NOTAMs will be maintained to identify locations with 5G C-band base station deployments. Further information could be referred to the FAA website <https://www.faa.gov/5g>.

Outcome of FSMP WG/13 on Radio Altimeter Issues

5.21 The meeting reviewed the outcome of the Thirteenth Working Group Meeting of the Frequency Spectrum Management Panel (FSMP-WG/13), held between 21-25 February 2022, on potential interference to Radio Altimeter from 5G for information and reference by the meeting. Under its Agenda Item 4 - Radio Altimeter issues, the following papers were discussed:

- Report from correspondence group on radio altimeters (CG-RA) - *IP03*
- National efforts to implement broadband mobile near 4200-4400 MHz
 - Mitigation measures - *WP03, WP16, IP02, IP04*
 - Safety Cases/Compatibility Analyses

The meeting was invited to note FSMP-WG/13 *IP/03*, which is the best overall fact-finding reference available today, while *IP/04* is more of a simplified “executive-level” briefing style text, they are provided in Appendices A and B to the paper respectively for easy reference. The Secretariat also

suggested the RTCA Technical Webinar: *Interference Risk on Radar Altimeters from Planned 5G Telecommunication* as a good reference at <http://www.youtube.com/watch?v=OpYhjK2MDqM>.

Update on Space-based VHF – Singapore

5.22 This paper presented the progress of Space-based VHF discussions at International Telecommunications Union (ITU) Working Party 5B (WP 5B) and ICAO Frequency Spectrum Management Panel (FSMP) working group meetings. With the support of ICAO and the different Regional Groups of the ITU, the space-based VHF frequency allocation was formally accepted as an agenda item for World Radiocommunication Conference 2023 (WRC-23). Currently, the space-based VHF frequency compatibility study is still ongoing in ITU WP 5B meetings, and the FSMP is the designated ICAO point of liaison with ITU WP 5B. The paper discussed the three documents updated in the ITU WP 5B meeting held from 29 November to 10 December 2021 including a Liaison Statement (LS) to ICAO to update the progress of space-based VHF studies and to seek clarifications, in particular, on VHF data link (VDL) Mode 2, a Working document towards a Preliminary Draft New Report (PDNR) detailing the technical studies and assessments of space-based studies, and a Working document towards a Draft Conference Preparatory Meeting (CPM) report that details the proposed regulatory changes for WRC-23. The paper also shared a document from FSMP WG/13 IP/06 regarding the initial outcomes of the technical studies and test/validations performed by a European initiative called VOICE, a project to perform a proof of concept (POC) for a satellite-based CNS technology in a real operational environment. The POC will also include satellite relay of VHF voice and data. As the activities within the ITU WP5B and the FSMP are intensifying as WRC23 draws nearer, to ensure aviation interests are safeguarded, the meeting was invited to support the agenda items as advised by ICAO Assembly Resolution A38-6 (*Support of the ICAO Policy on radio frequency spectrum matters*); and submit additional questions, if any, to FSMP through ICAO Regional Office.

Potential Impacts from 5G Implementation on Aircraft Radio Altimeters – Outcomes in Relevant Meetings and Regional Updates - Sec (WP/09)

5.23 To serve as a summary of discussion on the topic of 5G implementation and potential impacts on aircraft radio altimeters, this paper presented the discussion in APAC after CNS SG/25, and relevant regional updates, including Thirty-second Meeting of the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG/32), 11th Meeting of Regional Aviation Safety Group – Asia and Pacific (RASG-APAC/11), Sixth Meeting of the Spectrum Review Working Group (SRWG/6), 13th and 14th Meetings of Frequency Spectrum Management Panel Working Group (FSMP WG/13 and FSMP WG/14) and certain discussions in other bodies.

5.24 CNS Section of ICAO APAC Regional Office has received zero report on such interference in radio altimeters from the Member States or IATA so far. As a reminder of agreement in CNS SG/25, Member States would keep an eye on monitoring the impact of 5G on radio altimeters in their States/Administration regarding the safety and frequency spectrum issues. In parallel, it was advised that Member States CAA and airworthiness office may collect all relevant information and past issues reported, if any, and inform RASG-APAC in case of any significant concern. The issues related to frequency spectrum may be brought to the attention of CNS section of the ICAO APAC Office for further coordination with RASG-APAC and ICAO Headquarters.

Amendment 91 to Annex 10, Volume III on Selective Calling Codes - Sec (WP/24)

5.25 The Secretariat presented the main points of State Letter Ref.: AN 7/64.2.2-20/127 and the action required by the letter regarding the Adoption of Amendment 91 to Annex 10, Volume III issued on 9 December 2020, which concerns the expansion of the pool of selective calling (SELCAL) codes. The SELCAL amendment uses sixteen (16) new audio tones, in addition to the existing 16 audio tones, to create SELCAL codes from a total of 32 available audio frequencies (called SELCAL32). The air navigation services providers (ANSPs) are requested to upgrade ground systems (flight planning and SELCAL encoder) to support global implementation of SELCAL32 by 3 November 2022 and should consider taking the necessary steps to be compliant with the Amendment. The Amendment has also been reviewed by ACSICG/9 through WP/15, and ICAO Regional Office issued the State Letter Ref.:

T 8/4.3: AP107/22 (CNS) dated 10 August 2022 with the Subject of *Selective Calling (SELCAL) Code Pool Expansion* to remind the State/Administration to notify ICAO Headquarters (HQ) on any differences and compliance regarding Amendment 91 to Annex 10, Volume III before 3 October 2022, copy notifications to ICAO APAC Regional Office to share readiness status for the applicability of SELCAL32. The meeting was informed that China, New Zealand and Sri Lanka have been SELCAL32 compliant.

CAAC'S Support for the Enhancement of AeroMACS SARPs and Technical Manual - China (WP/26)

5.26 The paper presented the Civil Aviation Administration of China's (CAAC) support for the enhancement of AeroMACS SARPs and Technical Manual to be open to additional technologies, and shared the planned activities in the next step. China shared that the CAAC continues to support the development of the new-generation AeroMACS, and has issued a roadmap for the application of the new-generation aeronautical broadband communications in April 2021 to promote the advanced technologies implementation within the AeroMACS dedicated spectrum 5091-5150MHz. The efforts made by China have also been introduced. The CNS SG/26 was informed that with the support of the CAAC, the AeroMACS Forum has already commenced the initial analysis on the required revisions of AeroMACS SARPs and Technical Manual to make them less restrictive or technology specific, so as to give the ecosystem the flexibility to provide AeroMACS services using any additional technology (e.g., LTE, 5G) that meets the minimum performance characteristics and capabilities of AeroMACS. The revisions of the AeroMACS SARPs and Technical Manual, proposed activities, and schedule have been shared in detail. The meeting was invited to support the enhancement of AeroMACS SARPs and Technical Manual in the CP meeting.

Survey Result of the Introduction of 50 kHz Channel Spacing for ILS and VOR Facilities in the APAC Region - Sec (IP/03)

5.27 The ad-hoc group, which formed from SRWG/5 in 2021 to discuss the possible shortfall of VOR frequency channels with the current 100 kHz channel in the frequency band 108.000-117.975 MHz, reported the discussion outcome in the SRWG/6. The Group worked with the ICAO Secretariat and drafted a questionnaire for the APAC States and Airline Operators including IATA through State Letter Ref.: T 8/8.5 – AP067/22(CNS). 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 aircrafts operating in their airspaces are able to support the use of such 50 kHz channel spacing. It is encouraged that IATA would advise on their member airline operators about the capability of their aircrafts avionics in operating with 50 kHz channel spacing for ILS/VOR facilities. States should also confirm with other relevant bodies, e.g. Defence and Flying Service bodies, that use ILS/VOR facilities on their ability to operate with such 50 kHz channel spacing in their States. The results are planned to be further reviewed and discussed in SRWG/7 meeting in 2023.

Outcomes of APT-ICAO Webinar on 5G Implementation and Radio Altimeter – Sec (IP/04)

5.28 The APT-ICAO Webinar on 5G Implementation and Radio Altimeter (also known as *APT-ICAO Regional Dialogue: Radio Altimeters at 4200-4400 MHz band and implementation of 5G in adjacent bands*) was held on 23 August 2022 via Video Tele-Conferencing (VTC) on Zoom which was hosted on APT platform. The Webinar was intended to promote the common understanding among the spectrum regulators, the airlines and telecommunication industries on the operation of Radio Altimeters in the band 4.2 – 4.4 GHz and the implementation of 5G in the adjacent bands ensuring aviation safety in the Asia-Pacific region. The Webinar has registered with about **250** participants. There were four topics presented by spectrum regulators (APT), aircraft manufacturers (Airbus), aviation (ICAO) and telecommunication industries (GSMA), covering the each-different viewpoints and concerns from these entities, potential mitigation measures and future roadmap of complete resolution of the issue of co-existence of 5G implementation and radio altimeters. The webinar was well received by the participants, noting that the event served as a platform to bring together the national spectrum

regulators, telecommunications service providers, and the aviation community for direct engagement. Presentation slides and recording would be available on the ICAO Webinar website at <https://www.icao.int/APAC/Meetings/Pages/2022-Webinar-on-5G-Implementation-and-Radio-Altimeter.aspx>.

5G Network within Airport Boundary- Malaysia (IP/07)

5.29 This paper presented the safety concerns and safety recommendations for 5G network within airport boundary in response to ICAO State Letter on Potential safety concerns regarding interference to radio altimeters. The proposal for 5G network in Malaysia, categorized as new equipment or technology to be introduced within the airport boundary, has triggered the change factor and therefore, an SMS tool used (Management of Change and Safety Assessment) shall be established to identify safety concern of 5G network on the safety of aircraft operations. The paper introduced their management of change process and the safety assessment outcome, which determined safety recommendations to be taken up by the installer prior 5G network can be made available within the airport boundary. The safety recommendations are to furnish Malaysia Airports Holding Berhad (MAHB) with a report from Malaysia Communication and Multimedia Commission (MCMC) confirming the 5G signal allowed in Malaysia have no interference to aircraft operations and surveyed drawing of the 5G network coverage encroach onto aircraft approach path and radio altimeter protected area. As for aerodrome operator, a safety circular issued to all airports alerting 5G network shall not be allowed to be installed within airport boundary and to refer to Safety Office, MAHB.

5.30 On further enquiry, Malaysia stated that their 5G implementation frequency band do not exceed the use of those frequencies of radio altimeter. The Secretariat supplemented that the 5G potential interference issue to radio altimeter depends on various factors, including the radio altimeter itself, installation of base station and frequency bands used, which all contributed to the potential issue. In addition, Hong Kong China shared with the meeting their proactive work, which included formulation of a dedicated working group with the Hong Kong Civil Aviation Department, local telecommunication authority and local airport authority as members, who has been closely monitoring global development of this matter and the local situation. Although so far there has been no reported cases and no evidence that the local 5G base stations installed have caused interference to radio altimeters, the working group would continue their close coordination with the industry and local airlines to monitor the situation and ensure proactive measures are timely implemented to mitigate the possible interference from 5G to radio altimeters in Hong Kong China.

5.31 The CNS SG Chair advised that an ICAO Regional 5G Interference Workshop would be held on 16 November 2022 in Bangkok, Thailand and invited meeting members to join.

Verification of Air Traffic Control Services Based on Data-Link for All Flight Phases in China (IP/09)

5.32 The meeting was informed that guided by the thread of communication infrastructure (COMI) and communication service (COMS) in ICAO ASBU, Air Traffic Management Bureau (ATMB) of Civil Aviation Administration of China (CAAC) has carried out a series of technical feasibility verifications in Zhengzhou airspace since 2019, to optimize the use of China's aircrafts and datalink network and provide the fundamental base for full-scale application of Datalink Air Traffic Control Services in China's major airspaces in the future. With three years' research on the project of 'Technology and Application Research to support Datalink Air Traffic Control Services for All Flight Phases', China shared verification work conducted, regarding avionics systems, air-ground data-link communication network, and ATC information system, and summarized the service performance. The meeting noted that China will continue to carry out the operation verification of the mixed use of ACARS ATS and CPDLC data link services and accelerate the full-scale application of Datalink Air Traffic Control Services in China's major airspaces in the future.

Implementation and Application of VHF SELCAL in China (IP/10)

5.33 In order to prevent air-ground communication failure and enhance the safety of civil aviation operations, CAAC has conducted a series of work to improve the selective calling function.

Combining the requirements of the latest technical standards of ICAO and relevant research results, CAAC implemented SELCAL function on chief position of ACC center at VHF frequency as an effective approach to re-establish air-ground communication. China further elaborated on two technical solutions, frequency choice, and the control phase of implementing the VHF SELCAL, and summarized the operation and safety benefits.

Outcome of APG23-4 Meeting– Sec (IP/20)

5.34 This paper reviewed the outcome of the Fourth Meeting of Asia-Pacific Telecommunity (APT) Conference Preparatory Group for World Radiocommunication Conference 2023 (APG23-4), which was held on 15-20 August 2022 in hybrid mode of physical meeting at Bangkok, Thailand and Video Tele-Conference (VTC). 722 participants (with 291 in-person participation) representing 28 Members, 1 Associate Member, 33 Affiliate Members, 7 International/Regional Organizations and 1 other organization participated in the meeting. Regional Officers (CNS) from ICAO APAC Office were nominated to participate in the meeting, so as to:

- ensure correct inclusion of latest ICAO Position as the result of study progressed by FSMP based on latest ITU studies;
- monitor progress and status of Asia/Pacific regional preliminary views for WRC-23;
- protect aeronautical spectrum and support the ICAO Position at regional forums in accordance with APANPIRG/27 Conclusion 27/45; and
- report to relevant contributory bodies on the regional preparation progress made by APT APG.

ICAO representatives participated in various sessions of draft groups on agenda items relevant to civil aviation and provided necessary input and clarification as required, and engaged in lobbying with participants from civil aviation administrations and exchanged information and views with them. The outcome of the meeting is in line with the ICAO Position in overall. The Meeting was invited to note that 5th and 6th Meeting of the APT Conference Preparatory Group for WRC-23 (APG23-5 and 6) is scheduled for 20-25 February 2023 in Republic of Korea, and 14-19 August 2023 in Australia respectively. For information, WRC-23 is scheduled for 20 November - 15 December 2023 in Dubai, United Arab Emirates. The Secretariat mentioned under Agenda Item 1.9 *Digital tech for aviation safety-of-life applications* of WRC-23, APT Members are also of the view that the implementation of new wideband AM(R)S HF systems may require necessary coordination through ICAO given their role in organizing HF aeronautical channel plans in flight information regions. Although ICAO has no position and no function role in coordinate HF frequencies,, for States considering to conduct future studies on application using HF, ICAO APAC Regional Office could support and provide assistance in grouping the requests from Member States to facilitate wide band HF technology in future.

Agenda Item 6: Navigation

Review Report of PBNICG/9 – Sec (WP/10)

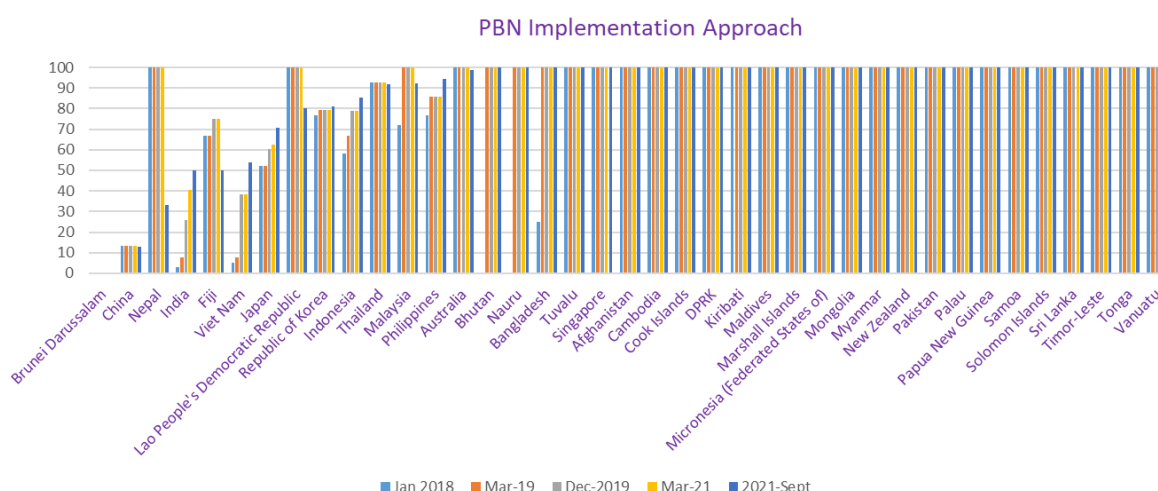
6.1 The paper provided information on the outcomes of the PBNICG/9 held through VTC from 22-24 March 2022 for the review by the meeting.

6.2 The Secretariat presented global PBN implementation status at international airports. The Secretariat also presented current implementation status of Asia/Pacific Regional Transition Plan for RNP APCH Chart Identification from RNAV to RNP. The Secretariat presented global PBN implementation status as available in ICAO iSTARS. ICAO informed that implementation of APV procedures for all instrument runway ends by 2016, key requirement of ICAO Assembly Resolution A37-11, was behind global achievement. However, implementation of PBN SID/STAR were above the global implementation status (see Table 1 and Chart 1)

Table 1. ICAO Assembly Resolution A37-11 Implementation Status as on September 2021

Sept 2021	LNAV	APV		PBN SID	PBN STAR
		LNAV/VNAV	LPV		
Global (%)	69.3	57.3	26.2	57.7	50.5
Asia/Pacific (%)	64.5	52.7	0	70	67

Chart 1. PBN (Approach) Update, as of September 2021(as per iSTARS)



6.3 The Secretariat informed the meeting that discrepancy about the list of International Airports in iSTARS and ANP had been resolved after extensive coordination with iSTARS team. This data is reflected in PBN Implementation of the States, and all APAC States should update their list of Airports in ANP Vol-I & Vol-II as urged by APANPIRG/31 in order to display a more accurate data of implementation.

6.4 The Secretariat presented the Implementation status of the regional transition plan for RNP APCH chart identification from RNAV to RNP, Asia/Pacific Regional Transition Plan for RNP APCH Chart Identification from RNAV to RNP as adopted by APANPIRG/30 vide Conclusion APANPIRG/30/14 (CNS SG/23/8-PBNICG/6/1). The Secretariat reminded the States about target date as November 2022 for RNP transition. The plan is available at the following link on ICAO APAC webpage: [Appendix B - Regional Transition Plan for RNP Chart Identification.pdf \(icao.int\)](#).

6.5 India, Indonesia, Myanmar, Pakistan and Thailand presented PBN Implementation progress in their States. India also presented a paper on implementation of RNP to XLS Approaches Facilitating Autopilot Coupling/Smooth Interception of Final Approach Track (LLZ). On Myanmar's information that the implementation of some RNP APCH procedures were delayed due to flight validation, the Secretariat informed the meeting about the provisions of ICAO Doc 9906(Vol-5) on the validation of procedures and requirement of flight validation.

6.6 The Secretariat presented the requirement of CDO/CCO Implementation as per APAC Seamless ANS Plan and ASBU Modules. Implementation, design, application and benefits of CCO/CDO was explained to help States in CDO/CCO Implementation.

6.7 Singapore raised a query about the requirement of implementation of PBN SID/STAR in a State as the operational requirements and needs are different in each aerodrome. The ICAO Secretariat explained the ICAO Assembly Resolution A37-11, which calls for the implementation of

PBN SID/STAR if the State considers it necessary for the efficiency of operation. It was further elaborated that data has been captured from iSTARS for international airports and if States want to discuss about the Key Indicators, it could be taken up in the next PBNICG.

6.8 Pakistan queried whether study was conducted on implementation of PBN SID/STAR for the improvement of efficiency of operation along with mitigation of emission and whether there is a threshold of traffic density recommended for implementation of PBN SID/STAR. The ICAO Secretariat explained that Assembly resolution A37-11 was adopted after several studies established the benefits of PBN SID/STAR in the improvement of operational efficiency and environment protection and PBN SID/STAR helps in the operational efficiency at medium to high density airports as PBN enables structured arrival and departure paths, which also helps in environment protection.

Review Report of GBAS/SBAS ITF/4 – Sec (WP/11)

6.9 This paper provides information on the outcomes of the GBAS/SBAS ITF/4 held through VTC on 11-12 May 2022 for the review by the meeting. Various States, including India, Japan, Republic of Korea, Thailand and the USA, shared updates about their GBAS/SBAS Implementation.

6.10 Co-Chair (Mr. Susumu Saito from Japan) of the task force presented status and outcomes from the activities of the Expert Group 3-1 for revision of the GBAS and SBAS safety assessment guidance documents related to anomalous ionospheric conditions and timeline for the work of the Expert Group 3-1. The group reviewed the GBAS and SBAS safety assessment guidance documents related to anomalous ionospheric conditions published in 2016, and identified points to be updated. The group targeted to deliver the first drafts of the guidance documents by fall 2022 and circulate the drafts to the Task Force members by December 2022. To achieve this, the group would have online meetings on a monthly basis. As the lead of Expert Group 3-1, India also presented outcomes from a review of SBAS Safety Assessment Guidance Document Related to Ionospheric Anomalies and those new proposed contents of the document.

6.11 On behalf of Expert Group 3-2 tasked to draft a guidance reference document for implementation of GBAS/SBAS in the Asia/Pacific Region, Co-Chair (Mr. George Wong from Hong Kong China) presented the outcomes from the review and discussion under Expert group for this task. The guidance reference document would be prepared to present a holistic view of implementation from the initial phase for the analysis of operational needs to the phase for conducting post-implementation review. States' experience in implementation of GBAS/SBAS and specific consideration(s), such as ionospheric impacts in low altitude region, only particularly applicable to the Asia/Pacific Region would also be incorporated in this guidance document to be prepared under Expert Group 3-2. Per the review conducted by the group, the structure of guidance document on implementation process for GBAS/SBAS and the timeline for drafting this guidance document for the Region as well as the regular expert group review meetings proposed by Expert Group 3-2 were deliberated and concluded in the GBAS/SBAS ITF/4.

6.12 Taking into account outcomes from the Task Force, a review on the current status of items in Action List was conducted and deliberated in GBAS/SBAS ITF/4. For those action items remained open, target dates were revised appropriately.

Update of Flight Inspection Guidance Material (FIGM) for APAC Region – China and Hong Kong China (WP/28)

6.13 The FIGM is subject to regular review and update for on-going development of flight inspection standards and recommended practices. To cope with the dynamic pandemic situation, new paragraphs were proposed to provide additional guidance on the advance planning for arranging flight inspections under pandemic situation. In addition, new paragraphs were proposed to adopt surveillance flight inspection to the safety-critical navigation systems as part of the commissioning flight inspection programme, and on the application of UAS for flight inspection. With the aforementioned, the following conclusion was formulated and adopted by the meeting.

Conclusion CNS SG/26/09 - Update of Flight Inspection Guidance Material (FIGM)	
What: That, the Edition 3.0 of the Flight Inspection Guidance Material (FIGM) provided in Appendix F to the Report be adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: The FIGM is subject to regular review and update, in the light of on-going development of flight inspection standards and recommended practices.	Follow-up: ☐ Required from States
When: 9-Sep-22	Status: Adopted by Subgroup
Who: ☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☐ Other: -	

ITU Circular Letter CR/488 on Prevention of Interference to GNSS - Sec (IP/05)

6.14 The ICAO Secretariat shared information about the Circular Letter CR/488 issued by the International Telecommunication Union (ITU) on prevention of interference to GNSS. With great concern about the increasing number and range of impact of such harmful interference on safety-of-life radiocommunication services used for the navigation of aircraft, the ITU issued the Circular Letter CR/488 with the subject *Prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band* on 8 July 2022. Consequently, the ICAO Regional Office issued the State Letter Ref.: T 8/5.10 : AP099/22 (CNS) dated 21 July 2022, Subject: *Prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band* to highlight the information with operators, service providers, and all stakeholders, sensitize the national radio regulatory Authority to the risk encountered by the civil aviation, and encourage States/Administrations to take actions to address this critical issue as appropriate.

BDS Standardization Status in ICAO – China (IP/11)

6.15 China provided 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. The declaration of BDS commissioning on July the 31st, 2020 accelerated the progress of the BDS SARPs development and validation progress in ICAO Navigation Systems Panel (NSP), which was completed by NSP in November 2020. The meeting was informed that the proposed amendment to Annex 10, Volume I to include the BDS core constellation was agreed to become applicable on 2, November 2023. China also shared the progress of other BDS related ICAO standardization work, including BDS related part in GNSS Manual and BDS related requirements in ARAIM SARPs, which will be submitted during NSP/7 for endorsement.

LEO Navigation Augmentation Concept, Constellation Construction Status and Civil Aviation Application Research in China (IP/12)

6.16 China provided the concept of Low Earth Orbit (LEO) navigation augmentation, the construction status of LEO navigation augmentation constellations, and preliminary research of LEO navigation augmentation civil aviation applications in China. The meeting was informed that LEO satellites, with their unique advantages in constellation and signal, are expected to become a new increment in the development of a new generation of satellite navigation systems. China shared that LEO navigation augmentation constellation is an important part of comprehensive national positioning, navigation and timing (PNT) system of China in the future. Some constellations have been launched experiment satellites for in-orbit verification, and experimental data of LEO satellite navigation signal and information augmentation have been accumulated. Combined with construction and development of LEO navigation augmentation constellations, China has performed preliminary research on

technologies and methods of LEO navigation augmentation civil aviation applications. It was added that LEO navigation augmentation constellation is optimized to increase Advanced Receiver Autonomous Integrity Monitoring (ARAIM) availability, which can provide suggestions for the construction of LEO constellations.

A Case of GNSS Signal Outage in the Oceanic Airspace in Japan (IP/15)

6.17 Japan Civil Aviation Bureau (JCAB) has been monitoring the service performance for air navigation at Network Performance Assessment Center (NPAC) since 2020. The paper presented the GNSS performance monitoring conducted by NPAC, JCAB, and shared a case study of the response to GNSS signal outage in Japan, which aimed to track the current situation of GNSS quickly and assess the impact of navigation accurately based on requirements and recommendations in Annex 10 Volume 1 and GNSS Manual (Doc 9849).

Research and Development Activities Related to GBAS in Japan (IP/16)

6.18 This information paper summarized the status of research and development related to GBAS in Japan, introduced the DFMC GBAS testbed (ground and airborne mock-ups, as well as ionospheric observation instruments) at New Ishigaki Airport, and highlighted two major subjects: 1) development of GBAS, including DFMC GBAS and GAST D, for challenging ionospheric environment and 2) advanced operations enabled by GBAS.

SBAS Status Update in Japan (IP/17)

6.19 As a part of SBAS implementation in Japan, MSAS (Michibiki Satellites Augmentation Service) started its operation for Japan's FIR on September 27th 2007. MSAS has been using QZSS (Quasi-Zenith Satellite System) GEO to take over the operation since April 2020. MSAS has been providing GPS Augmentation Information for RNAV/RNP, from En-route through NPA (RNP 0.3), and the trial operation of LPV/LP started on Dec 2 2021 based on the agreement with stakeholders. JCAB eventually aims to start the official operation of LPV-200 after 2023.

6.20 Considering GBAS/SBAS are the upcoming navigation technology, the CNS SG Chair suggested and China and Japan agreed to keep the CNS SG abreast of their latest development in the next CNS SG meeting.

Agenda Item 7: Surveillance

Review Report of the Seventh Meeting of the Surveillance Implementation Coordination Group (SURICG/7) - Sec (WP/13)

7.1 The paper reviewed the outcomes of SURICG/7, including the Fifth Meeting of Mode S Downlinked Aircraft Parameters Working Group (DAPs WG/5) and Second Meeting of the Surveillance Study Group (SURSG/2).

Outcome of Relevant Meetings on Surveillance

7.2 The meeting reviewed relevant information and updates on Surveillance and related matters arising from SURICG/6, CNS SG/25 and APANPIRG/32. The meeting noted the discussion during CNS SG/25 on points of contact for CNS for timely, effective, and efficient response from States/Administration, which was important in addressing CNS-related operational deficiencies notified to the Regional Office. The meeting supported the suggestion from the ICAO Secretariat on the need for DAPs WG to set up the list of Points of Contact for Mode S matters, such as the Mode S Interrogator Identifier (II)/ Surveillance Identifier (SI) code coordination. The SURICG Co-Chair suggested that States to present surveillance related implementation matters in SURICG or its contributory bodies meetings first before considering to present in higher level meetings such as CNS SG / APANPIRG.

Review Report of Mode S DAPs WG/5

7.3 The paper reviewed the outcomes of Mode S DAPs WG/5, and the papers and issues discussed are summarised below.

- APAC Regional Workshop on Mode S Implementation
- Update on Interregional IC Coordination
- Guidance Material for Assignment of Interrogator Codes (IC) for MLAT and ADS-B
- Reservation of IC Codes 14 and 15 for Research and Military
- Options for Vacating the SSR Mode S II Codes 14 and 15 in the APAC Region
- Update on Mode S IC Code Module in Frequency Finder
- An Abnormal Problem of CPR Decoding caused by the Incorrect Air-ground State of an Aircraft in China
- Mode S Interrogator Codes Allocation and Conflict Analyses
- Progress on the Trials of Mode S Surveillance Co-ordination Network in China
- Upper Air Wind Speed Estimation based on Mode S SSR DAPs
- Suggestions of Performance Parameters and Benchmarking of Radar System for APAC Region
- SI Operation Plan at Incheon Airport
- A GPS Interference Identification Method based on ADS-B Data
- An Evaluation Example of a Non-Cooperative Method for DAPS Data Recognition
- Management of 1030/1090MHz Utilization
- Roadmap on Mode S Implementation for APAC Region
- Planning Criteria for II/SI Code Assignment
- Updates to the Mode S DAPs Implementation and Operations Guidance Document

7.4 In Mode S DAPs WG/5 China proposed the revised draft of Edition 4.0 of the Mode S DAPs Implementation and Operations Guidance Document, developed based on the adopted edition 3.0. The revised draft supplemented the guidance material of ADS-B DAPs, including:

- Introduce ADS-B DAPs and their benefits
- Describe ADS-B DAPs data and the differences between Mode S SSR DAPs and ADS-B DAPs
- Supplement the mandate of implementing ADS-B DAPs, and the Mode S extended squitter transponder capability to broadcast ADS-B DAPs
- Add a new section to describe ADS-B DAPs broadcast by Mode S extended squitter
- Insert the application of ADS-B DAPs in the ATM automation system
- Give one example of ADS-B DAPs application

Other amendments included the revision of the description of the use of Mode S DAPs data for the weather forecast, the addition of a new appendix about guidance on measurement of 1030/1090 MHz usage. Upon review and discussion, CNS SG/26 endorsed the following Draft Conclusion:

Conclusion CNS SG/26/10 (SURICG/7/1 (DAPs WG/5/1)): Mode S DAPs IGD 4.0		
What: The Mode S DAPs Implementation and Operation Guidance Document Edition 4.0 provided in Appendix G to the Report be adopted		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: The revised draft includes ADS-B DAPs and adds guidance on the measurement of 1030/1090 MHz usage.	Follow-up: States	☒ Required from States
When: 9-Sep-22	Status: Adopted by Sub-group	
Who: ☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☐ Other: -		

7.5 SURICG/7 reviewed and deliberated the proposal from DAPs Working Group to rename the Group and update its Terms of Reference (ToR) to better reflect the current work scope that covers not only DAPs but also Mode S radars. After deliberation, SURICG/7 considered it appropriate to rename the Group as “Mode S and DAPs Working Group”, and endorsed the Decision SURICG/7/2.

Clarification of II/SI Code Allocation in Doc 9924 Appendices H and J

7.6 China, Singapore and the ICAO Secretariat shared the current proposals for amending the Aeronautical Surveillance Manual (Doc. 9924) Appendix H and J. Amendments in Appendix H will clarify the steps that can be taken to secure a safe introduction of Mode S II/SI capable interrogators and transponders with the focus on an environment where both Mode S II only and Mode S II/SI capable systems are being introduced. Amendments in Appendix J will update the Mode S II code assignment planning with Mode S SI code and provide for compatibility with Mode S interrogators and transponders that are not Mode S SI capable. Enhancement of the material would help States and regions migrate from II to SI under a mixed environment. Following the discussion at the Aeronautical Surveillance Working Group in Apr 2022, EUROCONTROL proposed improvements to the document. The meeting reviewed the latest proposal provided in the paper. The proposed text was still being worked out, and SP Chair commented that the enhancement work could be completed by SP/5 in fall 2023.

Review Report of the Second Meeting of the Surveillance Study Group (SURSG/2)

Surveillance Study Group: Progress Report, Recommendations in Study Report on surveillance sharing, and moving forward

7.7 SURSG/2 provided a progress summary of SURSG tasks since SURSG/1, lists out major recommendations in the Study Report and proposed way forwards for the recommendations for members’ discussion and decisions. SURSG/2 reviewed and deliberated the recommendations and moving forward proposals provided in the Table. The details of revised high-level recommendation and moving forward agreed by SURSG/2 was provided in the paper.

7.8 SURSG/2 deliberated the necessity for establishment of the Surveillance Sharing in SWIM Trial Implementation Group (S3TIG) to oversee such a trial proposed by the recommendation. China, Hong Kong China, IATA, Singapore, and Thailand seconded the proposal, with PCCWG also indicated its interest in participating in the trial. SURICG/7 discussed the proposal for establishment of S3TIG and suggested that it would be more effective to form S3TIG as an ad-hoc group within SURSG in lieu of a contributory body under SURSG. The SURICG/7 meeting also recommended to add ATFM SG into Liaison bodies in S3TIG and requested to add drafting and proposing surveillance data exchange model in the task list of S3TIG ad-hoc group. In addition, in SURICG/7, enquiries were raised on the difference between the adopted values of service level of shared data for Tiers 1 and 2 in the SURSG outcome and those specified in the AIGD. The Study group adopted the specifications from the AIGD v13.0, therefore, the abovementioned specification should be discussed and further reviewed. The meeting agreed to further discuss this matter.

Surveillance Data Sharing Proof of Concept

7.9 SURSG/2 discussed the Surveillance Data Sharing Proof of Concept (POC) conducted by HKCAD, PCCWG and Frequentis ComSoft. PCCWG shared the outcomes of a POC conducted on 4 March 2022, which was the collaboration of HKCAD, PCCWG and partner Frequentis ComSoft to demonstrate sharing ADS-B data in a simulated SWIM over CRV environment and the benefits of a Surveillance Central Data Processor (SCDP). PCCWG prepared a video to introduce the POC exercise which was presented in SURICG/7.

Implementation of FF-ICE Interoperability using GUF1 in SWIM

7.10 ROK presented its efforts to Implement FF-ICE Interoperability using Globally Unique

Flight Identifier (GUFI) in SWIM Environment. The SURSG/2 meeting noted that by introduction of GUFI to the surveillance data, it not only solved mismatch problems on co-relation between FPL and surveillance data by Call sign, DoF, departure/arrival aerodrome, but also made the co-relation become simple and reliable. Additionally, ROK shared the detailed method of introducing the GUFI in the surveillance information domain.

Review of Regional Requirements for Surveillance in APAC e-ANP and Seamless ANS Plan

7.11 The ICAO Secretariat reviewed and consolidated the Regional surveillance requirements specified in the APAC Regional e-ANP and the Seamless ANS Plan (Version 3.0, November 2019). States are encouraged to review TABLE CNS II-APAC-3 SURVEILLANCE in the Specific Regional Requirements in e-ANP Volume II, and provide update to ICAO APAC Regional Office as necessary through the PfA Process mentioned in the paper.

1090MHz Occupancy Monitoring

7.12 Singapore and ICCAIA discussed in this paper on the need to measure 1090MHz channel occupancy at flight levels as well as at ground level, and proposed some congestion mitigations. The paper suggested that congestion seen by receivers depends on “coverage volume. Various methodologies to avoid/reduce channel congestion at 1090Mhz were discussed and provided in the paper. States were encouraged to 1090 MHz channel occupancy monitoring at operating Flight levels and at ground level, and to always seek to minimise 1090MHz channel occupancy commensurate with their operational needs and environment.

The Sharing of the Software Resource for Benchmarking Radars

7.13 To address the need to access the radar performance among APAC ANSPs for maintenance and evaluation purposes, this paper proposed that each Member State to share the relevant radar analysis software for the radar benchmark. ROK introduced their radar analysis software “Astecat” developed by Incheon International Airport as one of the cost-free software tools for benchmarking radar performance that is openly shared for APAC States to use with no warranty and minimum maintenance support. The paper introduced the details of benchmarking of their surveillance systems, and their use of software in evaluating SI operation tests in Incheon International Airport. ROK was invited to provide their point of contact to ICAO on sharing their software.

Inconsistent ICAO Aircraft Address and Target Identification between Surveillance Data and Flight Plan

7.14 SURICG/7 noted the update on the observed discrepancies and contributing factors of ICAO Aircraft Address and Target Identification between surveillance data and flight plans for some aircraft flying within the Hong Kong Flight Information Region (HKFIR). More information could be referred to CNS SG/26 WP/30.

Suggestions of Performance Parameters of Radar System and Relevant Test Methods for APAC Region

7.15 China presented a minimal set of performance parameters that can effectively evaluate radar systems as the follow-up of SURICG/6 that an ad-hoc group was formed to study performance specifications and benchmarking of radar for APAC Region. China updated the minimal set of performance parameters from WP10 in DAPs WG/5 with the continued research on these documents, and provided the updated two minimal sets of radar performance parameters before and after updates with relevant test methods in the paper. Considering it an interesting paper that could benefit the Region, and China’s courtesy to share their research work documents with SURICG, the meeting agreed to include this useful information in this paper into a guidance document for the Region. The ad-hoc group was established to carry on the discussion of generating the proposed guidance document.

ADS-B Equipage and Quality Performance in the U.S.

7.16 FAA provided a summary of observed NIC/NACp performance compared to the requirements of the USA ADS-B mandate, as well as ADS-B equipage trends in the USA. The paper demonstrated how the performance benchmarking from airlines fleet were performed. FAA added that FAA's ADS-B Performance Monitor (APM) has capabilities for tracking ADS-B equipage trends. The paper further provided the FAA ADS-B coverage map at FL350, which extends somewhat beyond the airspace of U.S. ADS-B mandate.

Recent ADS-B Avionics Issues Observed in the United States

7.17 FAA described two recent ADS-B avionics issues observed in the USA with DO-260B/ED-102A systems, namely Embraer 17x track jumping and Honeywell Primus II RCZ. FAA informed that it monitors all ADS-B Version 2 information received in all airspace covered by FAA-contracted ADS-B ground stations via the tool ADS-B Performance Monitor (APM). In addition, FAA Flight Standards personnel have begun a campaign to reach out to aircraft owners, operators, and certificate holders that operate this equipment to inform them of the Service Bulletin available to correct the issue.

Performance-Based Operations Aviation Rulemaking Committee (PARC) Action Team (AT) Exemption 12555 Report

7.18 FAA presented the report by the Performance-based Operations Aviation Rulemaking Committee (PARC) to the FAA that contained an assessment of how well operators (exemption holders) will be able to achieve planned position source upgrades prior to the expiration of Exemption No. 12555 by December 31, 2024.

Study on Application Optimization and Improvement of ADS-B technology for CAAC Air Traffic Control

7.19 China introduced the outcomes of the ADS-B application study carried out by ATMB CAAC between 2020 and 2021, which stemmed from issues that affected the quality of ATC surveillance for the National ADS-B Project. This study was dedicated to standardising the construction and operation of ADS-B ground equipment in China, making them in better accordance with the needs of ADS-B operation in China.

An Anomaly of Mode A/C only Transponder Reply to Mode S Interrogation

7.20 China introduced a case where an aircraft equipped with the Mode A/C only transponder generated false targets in response to Mode S radar interrogation in January 2022, and explained how they analysed the causation of the phenomenon in combination with the relevant ICAO Annex 10 specifications, and provides some suggestions for Mode S radar manufacturers and aircraft maintenance engineers.

ADS-B IN Retrofit Spacing (AIRS) Evaluation Project

7.21 United States presented the updates to the ADS-B In Retrofit Spacing (AIRS) evaluation project after the introduction in SURICG/6 IP/08, a large-scale operational evaluation of two ADS-B In applications since September 2017, namely Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS) and Interval Management (IM). It was informed that the project aimed to promote early adoption of ADS-B In applications and benefits data will be gathered for one year after operation commenced.

Update on Air Traffic Control Surveillance Activities in Australia

7.22 Australia presented updates on their ATC surveillance activities including new radars,

sharing of surveillance data via IP based network, the upgrading of Sydney's ground display system with A-SMGCS integrated into the tower automation system, and replacement of ADS-B installations. Australia informed about a trial ground surface movement situational awareness system and a work on low-cost ADS-B avionics for VFR and added that future joint Civilian/Military Australia wide ATM system will provide a "Multi Sensor" surveillance tracking function. Australia is in the implementation phase of an Integrated Drone Surveillance System (IDSS) Trial.

Update on Surveillance Activities in New Zealand

7.23 New Zealand presented an overview of their current and planned surveillance activities on MSSRs, PSRs, Multilateration/WAM and ADS-B. ADS-B will be mandated for use within all controlled airspace in NZCC FIR by Dec 31, 2022. Their work on migrating data from surveillance systems to IP-based network over the last few years, and their use of UAS Traffic Management (UTM) system "Airshare" were discussed. New Zealand will continue to follow the use of low-cost ADS-B avionics such as electronic conspicuity (EC) devices. The paper also shared their new Air Traffic Management system "SkyX" to be operational in Q1 2023, and a joint project between Australia and New Zealand for the introduction of a Satellite-based augmentation system called the Southern Positioning Augmentation Network (SouthPAN) to improve GNSS accuracy.

The Update Activity of ATC Surveillance in China

7.24 China introduced their current status of civil ATC surveillance system and latest development, including Mode S radars, A-SMGCS, SMRs, MLAT and ADS-B ground stations, with local, regional and national data processing centres as their hierarchical processing infrastructure. CAAC actively carries out research on Mode S DAPs, and launched surveys on II conflict and II/SI mix operation capabilities for the APAC Region, launched Mode S Clustering trials in China, and conduct Surveillance Coordination Network (SCN) trials. The paper also presented the Development Plan for CNS approved by CAAC in 2021.

Introduction to the Test of the WAM Technology in the Final Approach Monitoring

7.25 China introduced the construction of WAM system for testing the final approach monitoring at Chengdu Shuangliu airport, and evaluated the position accuracy of the WAM data from 2020 to 2021.

Exploration and Practice of Electronic Handover in Complex Transfer Environment between Adjacent ATC units

7.26 China introduced the experimental operation of electronic handover in complex transfer environment between adjacent ATC units, gives and analyses the test verification results, puts forward the follow-up measures and plans.

Surface Security Enhancement Application Based on Voice and Photoelectric Intelligent Assistant

7.27 China shared the exploration and application of various new technologies that China put forward the application of panoramic photoelectric video and two-way recognition technology of tower control voice, to realize the application of airport scene intelligent security enhancement. The paper introduced the intelligent surface security assistant system at Shanghai Hongqiao Airport.

Evaluation of Space Based ADS-B

7.28 ICCAIA described how low-cost evaluation of Space based ADS-B at customer premises was supported. The space-based ADS-B provider, Aireon, has developed the capability to demonstrate and test the integration of Space based ADS-B into customer ATC automation systems. The paper also shared the experience and the way forward to arrange such evaluation.

ICAO Surveillance Panel Activities

7.29 Chair of the ICAO Surveillance Panel updated SURICG/7 about the information and discussions from the Fourth Meeting of the Surveillance Panel (SP/4) held on 28 March – 8 April 2022, including the two working groups of SP, i.e. the Fifteenth Meeting of Aeronautical Surveillance Working Group (SP-ASWG/15) and the Thirteenth Meeting of Airborne Surveillance Working Group (SP-AIRBWG/13). The paper also revealed the plan for SP/5 to be held in September 2023.

RTCA Status

7.30 RTCA introduced their operations as an independent standards development organization which supports ICAO, coordinates with EUROCAE and supports other organizations. Their non-profit nature supports various domains across the aviation industry. The presentation explained the background and objectives of SC-186 WG-4 with a summary of the activities of this group.

Review APAC Regional Surveillance Strategy

7.31 The Surveillance Strategy for the APAC Region is expected to be regularly reviewed to cope with the prevailing circumstances and developments. The ICAO Secretariat presented the last version of the Surveillance Strategy for the APAC Region adopted in 2019 for review. SURICG/7 reviewed the comments/views received for revising the Surveillance Strategy, discussed the amendment proposals, and formulated the revised Strategy provided in **Appendix H** to the Report which was further discussed and endorsed by CNS SG/26 through the following Draft Conclusion for consideration by APANPIRG/33:

Draft Conclusion CNS SG/26/11 (SURICG/7/3) - Revised Surveillance Strategy for the APAC Region			
What: That, the Revised Surveillance Strategy for the APAC Region provided in Appendix H to the Report be adopted.		Expected impact: ☐ Political / Global ☒ Inter-regional ☒ Economic ☐ Environmental ☒ Ops/Technical	
Why: To reflect the outcome of the latest development in surveillance technology.		Follow-up:	☒ Required from States
When: 09-Sep-22		Status:	Draft to be adopted by PIRG
Who:		☒ Sub groups ☒ APAC States ☒ ICAO APAC RO ☐ ICAO HO ☒ Other: SURICG	

7.32 Australia expressed that caution should be given on the Strategy item related to provision of multilayers surveillance to enhance surveillance service for meeting the contingency surveillance requirements might propose a misinterpretation to keep PSR coverage instead of SSR/ADS-B/other alternatives if GNSS outage observes. Co-chair of SURICG supplemented that the Strategy item should read in conjunction with another Strategy item stated to *reduce the dependence on Primary Radar for area surveillance*, which should ease the concern raised by Australia.

Positive Effect of CPR Reasonableness Test on ADS-B Security

7.33 Japan presented their reasonableness test for Compact Position Reporting (CPR) decoding is useful for improving ADS-B security via numerical simulation, and reducing false information that is intentionally transmitted. In Mode S DAPs WG/5, China presented the technique called reasonableness test for CPR Decoding, originally written in RTCA-DO260B. ENRI thus conducted a numerical simulation using this technique with the procedure, parameters and detailed

results provided in the paper.

Revision of Updates to AIGD

7.34 Hong Kong China led the discussion and incorporation of materials to update AIGD during the meeting with the methodologies to measure 1090MHz congestions and mitigating measures raised by Singapore and ICCAIA, and the CPR Reasonableness Test by Japan. The meeting agreed to formulate the following Draft Conclusion, which was reviewed and adopted by CNS SG/26 as follows:

Conclusion CNS SG/26/12 (SURICG/7/4) - Revised ADS-B Implementation and Operations Guidance Document (AIGD)		
What:	That, the revised ADS-B Implementation and Operations Guidance Document (AIGD) provided in Appendix I to the Report, which consolidated all change proposals during SURICG/7, be adopted as Version 15.0.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: Updates from SURICG/7	Follow-up:	☐ Required from States
When: 9-Sep-22	Status:	Adopted by Subgroup
Who: ☒ Subgroup ☐ APAC States ☒ ICAO APAC RO ☐ ICAO HQ ☒ Other: SURICG		

7.35 Hong Kong China clarified the reasons for the difference between the adopted values of service level of shared data for Tiers 1 and 2 in the SURSG outcome and those specified in the AIGD, and suggested a need to align the SURSG outcome as described in **Table 1 – High-Level Recommendations from Study Report** with the definitions of Appendix 6 of AIGD. It was decided that after deliberation, Hong Kong China will take up action to discuss with the Chair of SURSG to align the SURSG outcome with AIGD thus ensuring no misunderstanding and the specified performance requirements are suitable for the targeted services.

7.36 In response to the abovementioned action item, the Study Report was updated to align with the definitions of Appendix 6 of AIGD. The updated report was shared on 15 June 2022 via email with the focal point of voluntary Administrations/Organizations of SURSG and members who shared comments on Tier 1 and 2 values in SURICG/7. In response, Vietnam shared its concurrence with the study report and no feedback from other States/members were received. Therefore, the study report is updated after incorporating all the comments of SURICG/7. The revised study report is provided in Appendix E to the paper with updates marked in track change.

Amendment 91 to Annex 10 Volume IV - Introduction of ACAS Xa/Xo

7.37 The ICAO Secretariat presented the main points of State Letter Ref.: AN 7/66.2.2-22/27 Subject: Adoption of Amendment 91 to Annex 10, Volume IV was circulated to States on 29 March 2022 and the action required by the letter was to notify any disapproval before 18 July 2022; notify any differences and compliance before 3 October 2022; and consider the use of the Electronic Filing of Differences (EFOD) System for notification of differences and compliance regarding the Adoption of Amendment 91 to Annex 10, Volume IV, regarding the introduction of ACAS Xa/Xo, for review and action if necessary.

7.38 The Secretariat noted that the SURICG enjoyed the support from Surveillance Panel Chair and Members in this Region, and invited other members of Navigation Systems Panel and Communications Panel, etc. nominated from APAC States to proactively participate and support the work of different regional events.

7.39 CNS SG Chair expressed appreciation for the significant efforts by the SURICG and its contributory bodies to take forward various initiatives to enhance and harmonize the surveillance

capability of Member States/Administrations in the Region.

7.40 The CNS SG Chair proposed to initiate the required action to revise ICAO APAC Navigation Strategy, if necessary. The ICAO Secretariat will take essential action to review the ICAO APAC Navigation Strategy by offline discussion with the support of interested member States/Administrations. **ACTION ITEM 26-5**

ATS Surveillance and Direct Controller and Pilot Communication VHF Coverage Charts for APAC Region– Sec (WP/22)

7.41 The work and progress of updating the coverage charts of ATS Surveillance and Direct Controller and Pilot Communication (DCPC) VHF for APAC Region were discussed and expected to be incorporated in the next update of the APAC Seamless ANS Plan. The ICAO APAC Regional Office issued the State Letter AP027/22 (CNS) in February 2022 for States/Administrations to respond to the survey. With great assistance from Thailand, coverage charts on DCPC VHF and ATS Surveillance have been produced with highlights of changes discussed in the Meeting. The meeting endorsed to include the updated charts into the next update of Seamless ANS Plan. States/Administrations were encouraged to work with appropriate parties and/or other States/Administrations to derive plans in addressing the coverage gaps identified in the coverage charts, and States/Administrations which have not yet responded to the survey were encouraged to contribute relevant information to complete the coverage charts.

7.42 Australia noticed that the coverage only includes ground-based surveillance while States like Papua New Guinea which have already implemented space-based ADS-B in their airspace should also be considered. Despite not receiving input related to space-based ADS-B in this round of input/update, the Secretariat noted the comment and agreed to consider also the space-based ADS-B in future. The Secretariat also thanked Thailand for the meticulous work done and human resources paid to complete this task.

Inconsistent ICAO Aircraft Address and Target Identification between Surveillance Data and Flight Plan– Hong Kong China (WP/30)

7.43 The meeting reviewed the update on the observed discrepancies and contributing factors of ICAO Aircraft Address and Target Identification between surveillance data and flight plans for some aircraft flying within the Hong Kong Flight Information Region (HKFIR). Despite Conclusion CNS SG/25/13 (SURICG/6/7) endorsed to urge States/Administrations to proactively follow up with air operators to address discrepancies, the problems still persist and improvement in the overall situation has not been seen. Detailed analysis of the causal factors contributing to “Aircraft Address” (AD) / “Target Identification” (ID) discrepancies were provided in the paper and discussed in the meeting. The paper further discussed the remedial and preventive measures taken by Hong Kong China to mitigate the impact on operations caused by the recurring discrepancies. With this issue also discussed in SURICG/7, in that meeting IATA appreciated the effort by Hong Kong China and agreed to continue their effort to communicate with airlines for any ANSPs that encounter such discrepancies and IATA requested copying of these communications for following up with airline operators. CNS SG Chair highlighted that this could lead to concern on additional workload to ATC thus potential safety hazard to ATC operations, and the issue presented in this paper would still require further effort in the Region considering recovery in air traffic. As such, the Secretariat invited Hong Kong China and IATA to support ICAO APAC Regional Office to organize a webinar/workshop on this topic in 2023 to promote awareness of this issue and the best practice in mitigation. **ACTION ITEM 26-6**

7.44 IATA supplemented that they had already provided a detailed de-brief to airlines about the issue reported by Hong Kong China after the SURICG/7 meeting. The briefing specifically sensitized airlines on discrepancies and causes, and appealed to them for crosschecking and reminding their employees about the issue. IATA also reminded ANSPs to copy any communication with defaulting airlines on this subject so as to help operators in taking up the issue.

Research on ADS-B Position Verification - Japan (IP/14)

7.45 Japan summarized the outcome of the research on ADS-B position verification obtained in Electronic Navigation Research Institute (ENRI). The purpose of position verification is to detect false positions which may be caused by illegal transmissions or avionics failures. By experiment and computer simulation, ENRI recommended two effective methods: The time-Difference of Arrival (TDOA) method which has been incorporated into the AIGD, and the reasonableness test for compact position reporting (CPR) decoding which is to be incorporated into the next AIGD edition.

7.46 Co-chair of SURICG stated that the materials provided by Japan are informative and it was agreed in SURICG/7 meeting to incorporate them into the AIGD Ver. 15.0 as adopted in CNS SG/26, and CNS SG Chair encouraged the Region for more sharing from research and experiences to enable more members States could broaden the horizon in resolving issues observed.

Other Updates from States

7.47 New Zealand advised that Airways New Zealand signed a contract with Indra Spain to purchase 3 MSSR/PSR3D radars to replace the existing MSSR and PSRs which are nearing end of life. The new MSSR/PSR3D radars are to be used as a contingency system to provide surveillance coverage over the international airports at NZAA, NZWN and NZCH in the event of a sustained GNSS outage affecting New Zealand's prime surveillance coverage of ADS-B.

7.48 New Zealand would like to request ICAO Member States to update their airlines which operate into New Zealand, as of midnight Dec 31, 2022 (NZDT) or 202212301100 UTC that all controlled airspace within the NZZC FIR will become ADS-B mandatory airspace. Updated guidance for flight into NZ will be published in the NZ AIP towards the end of 2022.

Agenda Item 8: Automation

Review Outcomes of the Webinar on Air Traffic Management Automation System and the Third Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (ATMAS TF/3)- Sec (WP/14)

8.1 The paper summarised the discussion in the Webinar on Air Traffic Management Automation System and the work accomplished by the Third Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (ATMAS TF/3).

Webinar on Implementation of ATM Automation System

8.2 The Webinar on Implementation of ATM Automation System was organized in conjunction with the ATMAS TF/3 meeting on 7 June 2022. The Webinar was conducted in two sessions, the Session 1 focused on Practices Experience Sharing, while the Session 2 focused on System Integration and Interoperability. It provided the APAC region an update on the latest developments and practices related to ATM automation systems at global and regional levels. Total 8 comprehensive presentations from contributors were presented during the webinar.

Repository of the ATMAS in APAC

8.3 To follow up the Action Item 2-2 of ATMAS TF/2 to work out a revised repository of ATMAS implementation status in APAC, based on the draft table designed by Indonesia, the suggestions from ATMAS TF/2 and the latest version of the ATMAS IGD, the table of ATMAS status in APAC region was re-designed and re-formatted by the ad-hoc group led by Indonesia. The table of ATMAS status in APAC region has been reviewed and adopted by the ATMAS TF/3 meeting. While filling the table, the Member States are recommended to refer to the explanation of the table and the corresponding chapter of ATMAS IGD to get further information. The ICAO Secretariat was requested to issue a State Letter in due course to circulate the table to collect information in order to build the

repository of the ATM automation systems for APAC Region.

Updates on Development of Air Traffic Management Automation System Problem Reporting Database (ATMAS PRD)

8.4 Hong Kong China presented the updates and the latest progress on the development of ATMAS PRD as a follow-up action to ACTION ITEM 2-3. Further to discussion in ATMAS TF/2, it was considered more appropriate to separate the ATMAS PRD from ADS-B Avionics Problem Reporting Database (APRD), and with support from China, Hong Kong China has lined up with the software development resources from CAAC ATMB. Hong Kong China invited the ATMAS TF/3 meeting to further discuss on the database schemas for Report of ATMS-related issues and AIDC-related issues. States/Administrations were encouraged to nominate a point of contact for registration with the ICAO APAC Regional Office, and contribute to the development of ATMAS PRD.

8.5 The ATMAS TF/3 meeting agreed to add one agenda item for next meeting to encourage the States/Administrations to refer to the classifications of fault introduced by China, share valuable issues or problems encountered in ATM automation system, and discuss the necessity of ATMAS PRD.

Updates from States

8.6 Singapore presented its development of a prototype Secure Data Bridge (SDB) to extract historical and real-time data from the Air Traffic Management System (ATMS) in an automated, safe and secure manner that would be useful for ATM related functions and services. Singapore shared the concept of the SDB and the benefits of testing potential use cases safely outside of the ATMS.

8.7 Based on the polygonal MSAW warning area, China summarized the empirical data of SIDs/STARs procedures and the approach procedures, and proposed a new optimized MSAW around the airport combining four regions layer by layer in China. Through years of practical experience in China, the four regional segmentation settings, combined layer by layer, constitute the current optimal MSAW around the airport, and the advantages and disadvantages of each area alert have been elaborated.

8.8 China shared the experience in flight inspection of Air Traffic Management Automation System (ATMAS) in the Civil Aviation Administration of China (CAAC). The ATMAS TF/3 meeting was informed that CAAC has promulgated the ATMAS flight inspection technical requirements in 2011, and the recommended preparatory work, subjects, implementation, and follow-up work of the flight inspection have been summarized in detail.

8.9 New Zealand presented an overview implementation history of the new Air Traffic Management System (ATMS) that will be introduced into operation in 2023 and also highlighted lessons learnt thus far. The progress of requirements definition and system selection, development, re-sized implementation under Covid-19, and lessons learnt were shared in detail.

8.10 With this successful experience of Qingdao Jiaodong Airport realizing "overall relocation and overnight transition", China shared the hurdles in transition and relocation and analyzed the corresponding solutions. China informed that China will continue in-depth research and optimization of ATM automation system transition solutions under various transition modes with the help of advanced technology and management methods.

8.11 Philippines presented the impact of GPS Week Rollover to the ATM Automation System at Philippine Air Traffic Management Center. Philippines shared that based on this experience in using NTP servers, it is important to keep track of the hardware and/or software limitations as these may vary in the solution provided by the vendor.

8.12 China introduced the technical scheme of SWIM-based interoperability for ATM automation systems, built a test platform to verify the feasibility, and provided the summary of the

research. China summarized that through the studies and tests, SWIM-based interoperability of ATMAS is theoretically feasible, and expected to carry out practical exploration in the real SWIM network environment in future.

8.13 China presented the application of a data exchange platform among computer-based information systems related to air traffic services. China has set up the data exchange platform with four data exchange sub-platforms located in different physical locations, and introduced the structure of the data exchange platform and an application example of using sub-module of the data exchange platform in Capital Airport Tower.

8.14 Singapore presented its plans to implement FF-ICE/Release 1 (R1) and highlights the key considerations in planning for the Filing Services and Flight Data Request Services. Singapore has commenced planning in 2020 and plans to introduce two FF-ICE services by 2026. Furthermore, three key considerations that Singapore would be focusing on for FF-ICE implementation were elaborated. Singapore also opined that with increased participation, FF-ICE will mature faster and bring about more accurate and updated information exchanges allowing for a rich collaborative environment. The ATMAS TF/3 meeting was invited to explore opportunities to synchronize planning for FF-ICE implementation in the APAC region to achieve tangible benefits for all.

8.15 China introduced the new trends of controller training system development in circumstance of surging new technological applications, which can not only import airspace situation from ATM automatic system, extract flight information and generate exercise script, but also be used as a platform for airspace situation replay.

8.16 China introduced the arrival flight runway allocation optimization method in the AMAN aided decision-making function in the Guangdong-Hong Kong-Macao Greater Bay Area. This method is a runway allocation optimization method based on the minimum intersection and ground taxiing time, which can reduce air cross conflicts, controller workload and ground taxiing time.

8.17 To assist air traffic controllers under the enhanced wake turbulence separation scheme to improve consistency in handling arrival traffic at the Hong Kong International Airport (HKIA), Hong Kong China is implementing an Approach Spacing Tool (AST) for the final approach traffic. The AST has passed system acceptance testing and Hong Kong China is now adapting configuration of the system to fit it into the local operational environment which is currently planned for operation in 2023.

8.18 China presented the current cybersecurity status of ATMAS in China, and the brief design on 3 key aspects of cybersecurity in common between Air Traffic Management Security Manual (ICAO Doc 9985) and Chinese cyber security standard serial (GB/T 22239-2019). To downgrade the risks of ATM automation system, the whole ATM automation system is divided into 6 logical security domains according to their functions and the segregation measures and security policies between the 6 logical security zones were shared in detail. The ICAO Secretariat proposed that this paper could be presented in the ICAO cybersecurity webinar in the future.

8.19 China shared the status of the AIDC implementation in China, the progress of implementation with adjacent ATSUs in 2021, and the related issues and suggestions encountered during the implementation. China further updated the implementation of AIDC between China and seven adjacent ATS units, totalling 10 pairs of ATSUs with highlighted on explaining the progress and issues faced between Beijing ACC and Ulaanbaatar ACC AIDC and Kunming ACC and Vientiane ACC.

8.20 China presented the current AIDC implementation status of ATMAS in China, discussed the challenge of balancing AIDC packet delay and switching convenience when the main and fallback ATMAS are switched, and introduced further solutions. The pros and cons of the two methods in the AIDC message transmission by shared AFTN link and dedicated link when main and fallback ATMAS are switched were elaborated.

8.21 China introduced the CAAC Specification for ATMAS Part 3 Data Exchange to follow

up the ACTION ITEMS 2-4 of ATMAS TF/2 to translate the information on MH/T 4029.3 into English. China informed that the MH/4029.3 is intended to stipulate the requirements for flight data exchange between ATC and related systems. The advantages, applicable system, content composition, and system connections were shared in detail.

Air Traffic Management Automation System Implementation and Operations Guidance Document

8.22 The paper presented the revised draft (Edition 1.0) of the Air Traffic Management Automation System Implementation and Operations Guidance Document (ATMAS IGD) for ATMAS TF/3 meeting review. Following ATMAS TF/2 meeting ACTION ITEM 2-5, ICAO APAC regional office issued the State Letter AP173-21 (CNS) to gather further inputs and comments for the draft of ATMAS IGD. With 101 comments received from States, the ad-hoc group led by China, with the support of Hong Kong China and Singapore, worked on further improvement and polishing of the ATMAS IGD. Based on New Zealand's additional comments and suggestions during the ATMAS TF/3 meeting, the ATMAS IGD was further updated by the ad-hoc group for ATMAS TF/3 meeting review.

8.23 With aforementioned, the following Conclusion formulated by ATMAS TF/3 was adopted by CNS SG/26 meeting.

Conclusion CNS SG/26/13 (ATMAS TF/3/1) - ATMAS IGD Edition 1.0		
What:	The Air Traffic Management Automation System Implementation and Operations Guidance Document Edition 1.0 provided in Appendix J to this Report be adopted	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why:	The revised draft has been added the DMAN function and reviewed/updated with inputs from various States	Follow-up: ☐ Required from States
When:	9-Sep-22	Status: Adopted by Subgroup
Who:	☒ Sub groups ☐ APAC States ☐ ICAO APAC RO ☐ ICAO HQ ☒ Other: ATMAS TF	

Repository of AIDC Implementation Status in APAC

8.24 To follow up the ACTION ITEM 7-1 of APA TF/7 and considering the necessity of a comprehensive monitoring tool for AIDC implementation status in APAC region to support data statistics and analysis, the ICAO Secretariat designed a new table to maintain a common understanding between ATMAS TF and ACSICG on AIDC implementation, and eventually build up the regional repository of AIDC Implementation Status. The ACSICG/9 and ATMAS TF/3 have reviewed and adopted the format of the table of AIDC Implementation Status in APAC region with the current status. The ICAO Secretariat has incorporated the AIDC implementation status relevant information gathered before and will issue a State Letter in due course to circulate the table to States/Administrations for supplements and validation.

AIDC Implementation Issues Report

8.25 The ATMAS TF/3 meeting reviewed and discussed the consolidated implementation issues collected and presented by Indonesia with support from India and Singapore. Indonesia updated to the meeting that new reported AIDC implementation issues provided in the ATMAS TF/3 was 7 new issues. The number of AIDC implementation issues reported by members States/ Administration, based

on fault category are as shown in a table and chart:

Fault Categories	ATMAS TF/3 (2022)		
	Issues Reported	Closed	Open
a. Communication Link	9	6	2
b. ATM System	65	35	30
c. AIDC Message	23	14	9
d. Airspace Design/Procedures	13	7	6
e. Other	6	3	3
Total	116	66	50

Check List for ATMAS Project Management

8.26 To follow up the Action Item 1-2 of ATMAS TF/1, China developed check list for ATMAS project management from the scratch of planning, requirement definition, bidding, implementation to operational transition, and introduced the check list to Member States in detail. The meeting discussed and agreed to further polish the check list.

Agenda Item 9: Review and updates

Review of Regional CNS Requirements in ICAO APAC e-ANP, Seamless ANS Plan and National Air Navigation Plan (NANP) – Sec (WP/15)

9.1 This paper presented the Regional CNS requirements specified in the three Volumes of ICAO APAC e-ANP, Seamless ANS Plan (Version 3.0, November 2019) and updates on National Air Navigation Plan (NANP). The meeting participants were invited to review all CNS-related information affecting their administration in the e-ANP and provide feedback to ICAO APAC Regional Office to update as necessary. States/Administrations are also invited to formulate their NANP to comply with commitments to Beijing Declaration by 2022.

9.2 It was noticed that the information contained in e-ANP Volume I Table AOP I-1 – International Aerodromes Required in the Asia/Pacific Regions, and Volume II Table AOP II-1 – Requirements and Capacity Assessment in International Aerodromes in the Asia and Pacific Regions have been updated by various States. In this connection, the Table CNS II-APAC-2 Radio Navigation Aids, which contains the details of each runway in aerodromes, will need corresponding updates with inclusion of new aerodromes to reflect the latest status and align with tables aforementioned. States/Administrations should submit the updates through PfA process. Member States/Administrations were reminded to review and update all CNS facilities listed and CNS requirements specified in the e-ANP to verify that the information provided for their States/Administration is up-to-date and correct.

9.3 Noting the GANP to be reviewed in coming 41st Assembly, subsequently the review of the Asia/Pacific Seamless ANS Plan will happen after the 41st Assembly to make sure the Plan follows the latest version of GANP, subject to the arrangement of ATM Section of the Regional Office. In addition, States/Administrations were reminded the need to formulate their NANP to comply with commitments to Beijing Declaration by 2022.

Updates on Beijing Declaration Implementation Related to CNS – Sec (WP/16)

9.4 The ICAO Secretariat shared the information about current status of the Minister's commitment for 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 is to be implemented by 2022. The latest status of Ministerial Commitment for PBN implementation was reflected in graph-based on iSTARS tool updates, while current status of Common ground/ground telecommunication infrastructure to support ANS applications and Enhanced

surveillance capability including ADS-B technology were informed at the meeting based on the information updated during CNS meetings.

Updates on Seamless ANS Plan – Sec (WP/33)

9.5 The paper presented a proposal for the update of the Asia/Pacific Seamless ANS Plan for CNS SG comment. The CNS SG/26 meeting was informed that the update cycle of the Asia/Pacific Seamless ANS Plan was based on the intention that APANPIRG and its contributory bodies conduct a complete review every three years to align with the review cycle of the Global Air Navigation Plan (GANP). 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. Additionally, an initial summary of considerations for the update of the Seamless ANS Plan has been elaborated, and taking into consideration the GANP update cycle, it is proposed that the Seamless ANS Plan be updated during 2022/2023, and presented to APANPIRG Sub-Groups in 2023 before then being presented for the approval of APANPIRG/34 in 2023. The CNS SG/26 meeting was also informed that the Asia/Pacific Air Navigation Plan Volume III is intended to incorporate regional planning objectives, priorities and targets, implementation monitoring and reporting, and other regional guidance material, under the management of APANPIRG. The proposed change to the Seamless ANS Plan update cycle will be presented to the ATM/SG/10 meeting in October 2022, and then to APANPIRG/33 in November 2022 for consideration and agreement. The CNS SG/26 meeting has no further comment on the proposal raised by this working paper.

Update on ICAO GANP Study Group Related to CNS - Sec (IP/06)

9.6 The ICAO Secretariat presented the updates on ICAO GANP Study Group and shared the Working Paper from ICAO Council which contained the suggested changes in detail to the GANP to be presented to the 41st ICAO Assembly Sessions for meeting review. ICAO, following up on Recommendation 4.3/1 of the Thirteenth Air Navigation Conference (AN/Conf-13), established the GANP Study Group (GANP-SG) with a group of performance experts in June 2019, which worked on the updates of the Safety Performance Framework, ASBU Framework and BBBs. The Working Paper from ICAO Council which introduces the Seven Edition of GANP in detail will be presented to the 41st ICAO Assembly Sessions for endorsement. States/Administrations were invited to analyze this proposal and present their comments during the Assembly. Once the proposed changes are approved by the ICAO Assembly, the Secretariat will share the latest version with the meeting.

The Long-Term Vision for the Future Air Traffic Systems of Japan (CARATS) (IP/18)

9.7 The CARATS (Collaborative Actions for Renovation of Air Traffic Systems), as the Japanese long-term vision for the future of air traffic systems, was established in 2010, which defined goals and directions for renovation toward 2025. With the update of the 6th edition of the GANP, the planning horizon of the roadmap had been extended to 2040. Decarbonization is now a keyword to the sustainable future development of civil aviation and it should be made in response to corresponding to the growth in air traffic demand. JCAB is making a further review about CARATS with strong emphasis on decarbonization, while considering the improvement of the air navigation system through renovations, such as TBO, domestic airspace reconstruction, optimized take-off and landing. Information on the CARATS can be obtained from: <http://www.mlit.go.jp/common/000128185.pdf>

Global Developments Related to CNS – Sec (Presentation/02)

9.8 The presentation was prepared by Communications, Navigation, Surveillance and Frequency Spectrum Management (CNSS) Section and Airport Operations and Infrastructure (AOI) Section, ANB, ICAO HQ, which covered the outcomes and ongoing tasks from various working groups such as Communications Panel, Navigation Systems Panel, Surveillance Panel and Frequency Spectrum Management Panel in the first half of 2022. The presentation also briefly introduced the current status of the work owned by the Integrated CNS and Spectrum Task Force (ICNSS), and other CNSS activities

with a focus on the Frequency Finder tool.

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

Review Status of CNS Deficiencies – Sec (WP/17)

10.1 The paper presented the list of Air Navigation Deficiencies in the CNS field which was reviewed in APANPIRG/31. The only outstanding issue was related to unreliability of AFS communication between Afghanistan and Pakistan. Poor performance of AFS including data communication between Kabul and Karachi and ATS voice communication between Lahore and Kabul had become issues of regional concerns. A COM coordination meeting (Afghanistan, China and Pakistan) held in July 2019 in ICAO APAC Regional Sub-Office agreed to restore the VSAT connection by upgrading the VSAT terminals and equipment in Lahore and Karachi. Both Afghanistan and Pakistan were also agreed to implement CRV as soon as practical. However, there was no further progress after last update in 2020. The current List of Air Navigation Deficiencies in the CNS field was reviewed in CNS SG/26 and endorsed as **Appendix K** to this report.

10.2 The ICAO APAC Regional Office benchmarked Deficiencies in CNS fields in other Regions for information that is openly available. It was noticed that not all Regions identified Deficiencies in CNS fields. In addition, in the Ninth Meeting of ATM Sub-Group (ATM SG/9) held in 1-5 November 2021, WP/10 reviewed the IFALPA defined deficiencies. States/Administrations are encouraged to take note of CNS-related IFALPA deficiencies, and take proper action to address these IFALPA deficiencies.

10.3 Pakistan stated that they upgraded the hardware of VSAT from IDU 3000 to IDU 5000 in the year 2007. In addition, a VPN link was established between Karachi and Kabul through UK. Now the VPN link between UK and Kabul is un-serviceable. Pakistan identified that the data and voice communication through CRV is a workable solution. Pakistan Civil Aviation Authority has conveyed ICAO its intention to join CRV by December 2022. In the Meeting, Pakistan requested ICAO to provide assistance in establishing VSAT link and to coordinate with Afghanistan regarding their tentative timeline to join the CRV.

Agenda Item 11: 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 (WP/18)

11.1 This paper presented the regional ATSEP human factor guidance material for review and adoption and summarized the discussion and deliberations done in various Ad-hoc work group meetings held since last CNS SG/25 meeting in October 2021 for finding the left-out gaps and for preparing the regional ATSEP human factor guidance material. This paper also summarized the key concepts based on which the guidance material is prepared for assuring the mutual benefits to ANSP and ATSEP.

11.2 The meeting recalled that in response to APANPIRG Conclusion C 31/15, the State Letter Ref.: T 3/9.9- AP022/21 (CNS) dated 26 January 2021 on subject Addressing Human Factor Issues of ATSEP was sent by ICAO APAC Office. In response, Eight (8) States/Administrations (China, Hong Kong China, India, Indonesia, Japan, Republic of Korea, Singapore, and Thailand) nominated their experts, and the ad-hoc group led by IFATSEA was formed with the participants from Eight (8) States/Administrations and one International Organization namely International Federation of Air Traffic Safety Electronics Associations (IFATSEA) in April 2021.

11.3 The meeting noted that this Ad-hoc workgroup has conducted Twelve (12) meetings right from its establishment since April 2021. There has been a total of Seven (7) meetings conducted since the last CNS SG/25 meeting. Additionally, 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. The paper shared Roadmap, timeline, and tasks of the Ad-hoc workgroup meetings and proceedings and Principles adopted in the guidance material.

11.4 The guidance material was presented and discussed in the meeting. The meeting noted that there are five chapters with evaluation check lists namely (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, and (7) Work Environment, Well-Being, Performance, And Reward. In addition, the guidance material has the three chapters without evaluation check lists namely (8) Motivation, Commitment, And Engagement, (9) Behavioural And Role Specific Competencies, and (10) Safety Culture Promotion. The eight appendices are also added in the guidance material. These are (1) Stress factor mapping (2) Stress factors, (3) Counter measures, (4) ATSEP duty time limitation, (5) Measures during Pandemic, (6) Progressive Training, (7) Stress management and (8) Safety culture. It was added that with aforementioned, the ad-hoc group has completed the task for the preparation of ICAO ATSEP human factor guidance material.

11.5 The meeting appreciated the work completed by the Ad-hoc group in one year. The ICAO Secretariat suggested to share the guidance material with APAC Member States for their comments and observations. It was added that once feedbacks from APAC Member States are received and compiled, the Ad-hoc group may review the comments and modify the guidance material if required. After modifications, the revised ICAO ATSEP human factor guidance material may be presented to CNS SG/27 for adoption. The meeting agreed to the proposal. The ICAO Secretariat will share the State Letter to all APAC Member States to provide their comments on proposed ICAO ATSEP human factor guidance material in due course. **ACTION ITEM 26-7** The meeting encouraged member States to review the guidance material and respond to the State Letter in a timely manner.

Standardizing the ATSEP Training for the Successful Implementation of the GANP - Nepal (WP/25)

11.6 Nepal shared that aviation professionals have an essential role in the transition to, and successful implementation of the GANP. It added that the system changes will affect the work of many skilled personnel in the air and on the ground, potentially changing their roles and interactions and even requiring new proficiencies to be developed. Furthermore, with the expected growth of aviation, it is critical that enough qualified and competent personnel are available to ensure a safe and efficient aviation system. Therefore, according to the Doc 9750-AN/963 Fifth Edition – 2016 “Global Air Navigation Plan 2016-2030, for the safe air transportation system along with managing the risks associated with human performance and proactively anticipate interface and workstation design, need of the training for Air Traffic Safety Electronics Personnel (ATSEPs) utilizing competency-based training methods is essential.

11.7 The meeting was informed that Doc 10057 has recommended the ATSEP training be organized in the following Phase 0- Selection, Phase 1- Initial training, Phase 2- Unit training, Phase 3- Continuation training, and Phase 4- Development training. Although, Doc 10057 has recommended the Training Objectives for the basic training courses, specifying the initial training for the priorities modules of ASBU as an integral part of GANP, such as B0 ACDM, B1 ACDM, B0 DATM, B1 DATM, B1 SWIM, B2 SWIM, FF-ICE are not included in Doc 10057. As part of the Next Generation of Aviation Professionals (NGAP) programme, training, educating and retaining the next generation of aviation professionals, the basic training of the above ASBU module shall be included in Doc 10057, “Manual on Air Traffic Safety Electronics Personnel, Competency-based Training and Assessment” for the successful implementation of the GANP.

11.8 The meeting was invited to identify the training needs of ATSEPs in some important ASBU modules like B0 ACDM, B1 ACDM, B0 DATM, B1 DATM, B1 SWIM, B2 SWIM, as suggested by Nepal, for the successful implementation of GANP and incorporate the ASBU module described above in Doc 10057, “Manual on Air Traffic Safety Electronics Personnel, Competency-

based Training.

11.9 IFATSEA shared that scope to include ASBUs are already covered in the document 10057, such as to follow SARPs, regional and global policies etc. Additionally, inclusion of ASBUs into basic or qualification training as separate subject, if required, should be deliberated in the expert group at ICAO HQ.

11.10 After some deliberation, the CNS SG Chair shared his views that the “important” ASBU modules may be different from the prioritised ASBU modules in the APAC Seamless ANS Plan, and that basic training module covering International and national organizations and standards, Air traffic services, airspace standards and meteorology, CNS/ATM concepts may include general terminologies of ASBU modules and human factors. Additionally, qualification training modules may group ASBU modules into specific modules such as Communications, Navigation, Surveillance, Information Management including cyber security, etc.

11.11 The ICAO Secretariat noted the deliberation and will work with IFATSEA to share with the relevant expert group of ICAO HQ and the deliberation be evaluated along with other topics identified as valuable to the ATSEP training objectives, such as cybersecurity as proposed by other stakeholders in Assembly 41. **ACTION ITEM 26-8**

Agenda Item 12: Cybersecurity of CNS/ATM systems

Updates on ICAO International Aviation Trust Framework- Sec (Presentation/01)

12.1 The ICAO Secretariat shared the recent development ICAO’s work on building an International Aviation Trust Framework since CNS SG/25, including developments of TFSG, information security framework (ISF), new proof of concept exercise, and digital identity. The meeting was informed that several papers on the trust framework and cybersecurity received for A41, and ICAO is working on SkyTalk and sidebar meeting to promote cyber activities within ICAO.

Ensuring Cyber Resilience for Air Navigation Service in Hong Kong International Airport and its Expansion (WP/31)

12.2 Hong Kong China shared their experience in provision of an effective cyber security management framework to ensure safe and secured air navigation service (ANS) for supporting the operation of Hong Kong International Airport (HKIA) and its expansion into Three Runway System, with high digitization and interconnection put in place. The paper introduced the establishment of Air Navigation Services Cyber Security Committee (CACSC) by Hong Kong Civil Aviation Department (CAD) to steer the implementation of cyber security control measures throughout the whole life cycle of ANS systems to manage risks of cyber security threats while maintaining confidentiality, integrity, availability and safety in provisions of ANS to the aviation stakeholders. The paper further introduced the documentation developed to promulgate cyber security policies and implementation guidelines to all the stakeholders concerned, with internal assessments conducted to ensure the effectiveness of various control measures. In addition, The Cyber Security and Technology Crime Bureau (CSTCB) of the Hong Kong Police Force (HKPF) has been working in hand with CAD to conduct independent assessments and make recommendations, including the establishment of a communication mechanism for CAD to seek swift assistance/advice from the CSTCB for sharing intelligence and in the event of cyber security incidents, and regular drills performed jointly by CAD and CSTCB. To cope with the expansion of the HKIA into 3RS, a new ATC tower was implemented with new ANS systems of high-degree digitization and interconnection. CAD has engaged an independent assessor to carry out an independent assessment on cyber security, which confirmed that there is no cyber security risk. The paper invited States/Administrations to share their experience and make reference to the guidelines and best practices promulgated by ICAO or other international organizations in developing a robust and effective cyber security management framework.

Agenda Item 13: Discuss and share experience and application of new technologies, including big data analysis, artificial intelligence, Digital Tower, counter UAS detection and identification system, UTM, etc.

13.1 Under this agenda item, in response to APANPIRG's call on enhancing engagement with the industry, CNS SG invited various industry partners to share and update the latest progress in relevant areas.

Trial Flight and Standard Establishment of UAS-Based Flight Inspection in China (WP/27)

13.2 China provided the trial flight information and standard establishment progress of UAS-based flight inspection in China. China informed that the R&D team has been developing a leading and practical flight inspection technology based on the fixed-wing and hybrid-wing UAS, which was tested and validated in several trial flights. The detailed solution and result of the trial flights have been introduced through a PowerPoint attached. In 2021, based on the achievements obtained from R&D and trial flights, Civil Aviation Administration of China (CAAC) proposed a standard and regulation establishment plan covering UAS, mission payload, inspection specification, crew qualification, routine maintenance and operation, to guide and encourage UAS-based flight inspection development and application. The meeting was invited to discuss the trial flight solution and result, review the three parts of the standard and regulation establishment plan, and promote UAS-based flight inspection technology application.

13.3 Considering UAS-Based flight inspection is the upcoming technology, the CNS SG Chair invited and China agreed to keep the CNS SG abreast of their latest development in the next CNS SG meeting.

Provision of a Digital Tower and Apron Management System to Support Safe and Efficient Operation of the Hong Kong International Airport and its Expansion (WP/29)

13.4 To support the expansion of the Hong Kong International Airport (HKIA) into Three Runway System, Hong Kong Civil Aviation Department (CAD) has partnered with Airport Authority Hong Kong (AAHK) to implement a Digital Apron and Tower Management System (DATMS) under roadmap of the ICAO Global Air Navigation Plan. With the first phase commissioned in July 2022, the DATMS comprises two systems, namely Digital Tower Facilities (DTF) which provides enhanced visuals of air and ground movements or supplement out-of-sight for ATC purposes, and Digital Apron Management System (DAMS) which caters for airport operation. The features and benefits of DTF and DAMS were introduced in depth in the paper. The implementation of DATMS enhances information exchange and real-time situation awareness between air traffic controllers and airport operational personnel, fosters closer collaborations and facilitates decision-making, all of which are conducive to further improving the safety and efficiency of the overall ATC and airport operations. It sets a good example of further enhancing the safety and efficiency of busy airports, especially during the period of air traffic recovery. A harmonized approach with common standards and guidance materials is recommended to facilitate the implementation of Digital Tower and Digital Apron technologies worldwide. The paper encouraged States/Administrations to share their experience in the use of advanced technologies in busy airports to support safe and efficient provisions of air navigation service, which is of particular importance for air traffic recovery.

Development of Digital Tower Prototype at Changi Airport – Singapore (IP/08)

13.5 The paper highlighted the overall experience and lessons learnt from the development of a digital tower prototype at Changi Airport. The meeting was informed that the Civil Aviation Authority of Singapore (CAAS) embarked on a research study in 2015 to evaluate a digital tower concept for high-intensity runway operations at Changi Airport. The research study then concluded that there was scope to develop a digital tower solution for Changi Airport which could reap numerous operational benefits, including enhanced situational awareness and visibility, improved line of sight,

and enhanced safety and operational efficiency. Singapore summarized the development of the digital tower prototype, shared the challenges and lessons learnt, and introduced future plans to evaluate the next steps required to progress from a prototype system to deploying digital tower technologies in an operational environment.

13.6 Considering the Digital Tower technology had triggered favourable response from APAC members, the CNS SG Chair suggested and Hong Kong China and Singapore agreed to keep the CNS SG abreast of their latest development in the next CNS SG meeting.

Comprehensive Applications of the Radar-based Monitoring Systems in Airport - CETC Glarun (Presentation/03)

13.7 CETC Glarun Technology presented various monitoring requirements of airport operation, as well as the site specific restrictions in terms of radio frequency, installation, power supply and communications. The proposed comprehensive solution for Hong Kong International Airport is based on a comprehensive application of radar-based movement monitoring system, Radio Frequency detection, Electro-Optic (EO) sensor and Automatic Identification System (AIS) which comprises UAS Detection System (UASDS) and Taller Vessel Movement Monitoring System (TVMMS), with AI capability, to better protect the airport operation.

Digital Towers: Resilience, Recovery, Refocus – Searidge (Presentation/04)

13.8 Searidge Technologies highlighted the Resilience, Recovery, Refocus as its 3Rs concept applied in the process to implement digital tower. They explained that Resilience is to maintain essential services and address contingency, Recovery provides scalable solutions to adapt emerging business cases and system integration, Refocus utilizes technology to make operations more sustainable, flexible and efficient in broader industry sectors. Digital Apron and Tower Management System (DATMS) in Hong Kong was discussed as applications for ATC tower & airport apron management.

Advanced Digitization Facilitating Air Traffic Development- Huawei (Presentation/05)

13.9 Huawei presented its observation on global digital transformation for the aviation industry, and the challenges of integrating technologies, data and services. Huawei proposed upgraded connectivity, renewed platform and augmented intelligence to empower smart air traffic control in meeting the new requirements on full situational awareness, intelligence-assisted decision making and operation assurance, as well as a Data Governance model for Air Traffic Management.

Experience Sharing on Digital Towers – SAAB (Presentation/06)

13.10 Saab shared its experiences on digital towers as an integral part of ATM and airport digitalization. Saab presented their generic remote/digital tower setup, multiple use cases solution, air traffic services on demand, optimization of today and future, flexible and resilient configuration, and the fields of research.

Agenda Item 14: CNS related work/projects impacted by COVID-19

Impact of COVID-19 to CNS Works in 2022 – Sec (WP/19)

14.1 The ICAO Secretariat summarised the impact of COVID-19 on CNS works in 2022. It included the CNS meetings scheduled for 2022 by VTC, the organisation of a series of webinars for easier access to ICAO events, and increase in the number of participants than face to face meeting. The CNS SG Chair suggested that Hybrid meeting could be considered for the future meeting or workshop which topic requires wider coverage. The meeting noted that due to the decline of implementation of CNS/ATM projects by the Member States, the planned programme has been postponed or has broken into phases and the harmonisation of implementing activities between neighbouring States and among

stakeholders became more difficult. The meeting noted that concerning the development of the COVID pandemic to the aviation development in APAC Region, DGCA/57 has raised several Action Items stemmed from recovery of COVID situation. The details of Action Items related to CNS are presented in WP/04 of CNS SG/26.

Agenda Item 15: Any Other Business

Tracking CNS-Related APANPIRG Conclusions/Decisions – Sec (WP/12)

14.2 The ICAO Secretariat presented the CNS-related APANPIRG Conclusions/Decisions summarized in the excel table with marked of current status for review and action by the meeting. In view of the importance of the APANPIRG Conclusions/Decisions, the Secretariat has reviewed the reports of the former meetings from APANPIRG/1 to APANPIRG/32, and extracted more than 600 CNS-related APANPIRG Conclusions/Decisions from the reports on various media and consolidate in one Microsoft Excel table with marked status as *in force/applicable, closed, not applicable, group dissolved, superseded, task completed, and undertaken by ICAO HQ/Panels*, for easy reference and tracking by States/Administrations, which is provided in Appendix to this Paper.

CNS Points of Contact – Sec (WP/20)

15.1 The ICAO Secretariat reviewed and updated the CNS Points of contact of ICAO APAC Member States and requested States/Administrations to provide the latest information about CNS points of contact for contingency planning and administrative support for effective and efficient coordination. The Regional Office has requested States/Administrations to provide points of contact for urgency and administrative purposes in the CNS domain for a few years. As of early August 2022, the office received the corresponding information from 17 States/Administrations, which was provided in the paper. States/Administrations that have yet to provide their CNS Points of Contact were urged to provide the required information by sending an email to the ICAO APAC Regional Office at apac@icao.int. States/Administrations already provided the information were requested to share updates if any at the same email addresses. The updated CNS Points of Contact are provided in **Appendix L** to the Report.

Flight Inspection Capability Building of CAAC for CNS Facility - China (IP/13)

15.2 China provided a brief introduction to the Flight Inspection Center of CAAC (CFI) which was established in 1989. China shared that during the last 30 years, CFI has committed to developing the inspection capability and playing an active role in international meetings, symposiums, and webinars, including CNS meetings. The meeting was informed that CFI serves 248 transport airports in China, and checks over 1700 facilities per year, which provides commissioning, periodic and special flight inspection and validation for conventional and New Tech facilities. Through the communication and cooperation among CNS Facilities, CFI expressed their willingness to contribute to the conventional or satellite-based technological exchange, ICAO SARPs introduction and digestion, take active participation in the establishment of ICAO SARPs and relevant program implementation in Asia-Pacific area, and provide high quality flight inspection and validation services for CNS Facility.

IATA's Aircraft Equipage and Capability Survey – IATA (IP/23)

15.3 IATA presented a progress analysis of airline responses to ongoing IATA's Aircraft Equipage and Capability Survey for Asia-Pacific and North Asia conducted in Quarters 1 and 2 of 2022.

15.4 IATA informed that in recent years there have been multiple queries about fleet capabilities during ICAO meetings and other workshops dealing with CNS requirements and possible mandates. Unfortunately, the most recent and complete information isn't always available, and IATA needed to conduct many smaller ad-hoc surveys to meet action items. Understanding that a lot has and is still changing throughout and post-COVID, it was identified as an opportune time to conduct a broad and detailed survey in order to build a detailed baseline database for operators in APAC region. As industries are still in recovery mode from COVID-19, the IATA Aircraft Equipage and Capability

Survey asked member and non-member airlines for responses that projected forward in a window of where fleet capabilities will be by the end of the 2022 calendar year.

15.5 The meeting was informed that to date responses have been received from 26 airlines which include most major airlines based in APAC, several that are based in other regions but operate here, and several other airlines from within the region. Responses are still being sought in order to continue building the database which currently records equipage and capability data for over 4200 aircraft. IATA shared preliminary analysis of data from the responses received to date for the specified categories across the individual and generic fleet aircraft types.

15.6 IATA informed that it will continue to collect data from the survey and produce summaries that can support and inform future discussions within ICAO and other forums. More specific analyses will be conducted once all data is fully filtered and collated and will be based on specific discussions that will benefit from the outputs from the database. IATA has agreed to support and share relevant information with the APAC members based on their specific needs to better use the survey information.

The CNS SG/26 Meeting Action Items

15.7 There are **eight (8)** action items identified in the CNS SG/26 meeting, the summary of action items is provided in **Appendix M** to this Report.

Agenda Item 16: Date of next meeting

Member States' Support for Contributory bodies Meetings in 2023- Sec (WP/21)

16.1 The paper presented the following schedule of the CNS contributory bodies meetings to be held in 2023, and requests APAC Member States to support the ICAO Secretariat in conducting the CNS SG and CNS contributory bodies meetings in effective manner.

No.	Name of meeting	Dates	Mode of Meeting	Venue
1.	CRV OG/11	25-27 January	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
2.	SRWG/7	TBD (Mar/Apr)	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
3.	DAPS WG/6	March	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
4.	PBNICG/10	March	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
5.	SURSG/3	11-13 April	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
6.	ACSICG/10	May	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
7.	SBAS/GBAS ITF/ 5	May	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
8.	SWIM TF/7	May	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
9.	SURICG/8	June	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok
10.	ATMAS TF /4	June	Face-to-face /Hybrid /VTC	Chengdu, China (Tentative)
11.	CNS SG/27	July	Face-to-face /Hybrid /VTC	ICAO APAC Regional Office, Bangkok

16.2 The ICAO Secretariat will inform Member States about the exact dates, mode and venue of the meeting while issuing invitation letters in due course.

Note of appreciation

16.3 On behalf of the CNS SG, Mr. Richard Wu, the Chair of CNS Sub-group, expressed thankfulness to the ICAO Secretariats for their excellent support and dedication in ensuring smooth running of the CNS SG/26 meeting within the tight timeframe.

16.4 Mr. Richard Wu expressed his appreciation to all participants from Member States/Administrations, International Organizations, and sponsoring industries for their significant contributions and active participation in making the meeting a successful and fruitful one. Mr. Wu gave a brief summary on the achievements by the CNS Sub-group in this meeting while highlighting the key issues discussed and addressed. He shared that with the strong dedication and unfailing support from all the Subject Matter Experts, the CNS Sub-group would upkeep our professional work and momentum to ride on the pandemic storm while gearing up ourselves for traffic recovery. He envisaged the CNS Sub-group would continue taking a significant role in shaping the future direction of CNS development for this region. He looked forward to meeting the APAC members face-to-face in next year.

16.5 The ICAO Secretariat shared its appreciation to Mr. Richard Wu, the Chair of CNS Sub-group for operating CNS SG/26 meeting in a timely and efficient manner. Lastly, the ICAO Secretariat expressed its gratitude for contribution and support from APAC Member States, international organisations, and industry partners.



INTERNATIONAL CIVIL AVIATION ORGANIZATION

ANNEX 1 TO THE MANAGEMENT SERVICE AGREEMENT BETWEEN THE INTERNATIONAL CIVIL AVIATION ORGANIZATION AND THE CIVIL AVIATION AUTHORITIES AND/OR RELATED AIR NAVIGATION SERVICE PROVIDERS HAVING SIGNED THE AGREEMENT

Project Title: Common Regional Virtual Private Network (CRV) multinational service with a common service provider

Project No.: RAS/14/801 – Revision B

Duration: 5 years

Sector and Sub-Sector: Transport and Civil Aviation

Country Implementing Agency: Civil Aviation Authorities and/or related ANSPs

Executing Agency: International Civil Aviation Organization (ICAO)

Location: Asia Pacific

Estimated Start Date: 31 March 2022

Estimated Project Cost: US\$ 88,000

Brief Description: Under Revision B, ICAO will assist the Civil Aviation Authorities and/or related ANSPs in the continuation of the APAC CRV Project through the provision of expertise and support to the CRV Network (Stage 2). The ICAO assistance covers the specific work scope outlined in this project document.

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1. BACKGROUND

1.1 The Civil Aviation Authorities and/or related ANSPs as listed in Appendix A, hereinafter collectively referred to as the “Parties” and individually as the “Party”, have determined that the Common Regional Virtual Private Network (CRV) multinational service with a common service provider can more effectively:

- provide network services to the Parties;
- support a common Internet Protocol (IP) network;
- establish services based on Voice over IP (VoIP); and
- enhance network diversity and timely service implementation and delivery.

1.2 In 2014, all Parties jointly agreed to appoint ICAO Technical Cooperation Bureau or TCB to assist in the procurement management (i.e. Stage 1) of the CRV project and in the selection of the common Service Provider (RAS14801 Revision A). Upon selection of the common service provider after a Sealed Tender (ST) process through TCB, each Party were expected to subscribed to the Services by signing an individual Service Contract with the Service Provider for the procurement, installation, training, testing, commissioning and operation of the CRV network and the associated services.

1.3 After selection of the common service provider in 2016, a fund balance of USD 104,596 remained as on 31 March 2017. CNS SG/21 (17 to 21 July 2017) and APANPIRG/28 (11 to 14 September 2017) agreed to manage the remaining funds not used for the CRV selection process, to procure common services or expertise to support the implementation of the CRV Network (Stage 2).

1.4 As at 31 December 2021, the remaining fund for use are approximately USD 88,000 allowing for the return of funds to two pioneer Member States in terms of the Conclusion APANPIRG/28/19 “Amendment to the Management Service Agreement for CRV Project (RAS14801)”.

1.5 As a result of the discussions between the Parties, Revision B has been developed to utilise the carry-over funds from the completion of the activities of Stage 1 to procure common services or expertise to support the implementation of the CRV Network (Stage 2).

2. SCOPE OF SERVICES TO BE PROVIDED

2.1 Through this Revision, the following services will be provided by ICAO within the scope of supporting the CRV Network (Stage 2), as may be required:

- a) Provision of expertise through engagement of subject matter experts;
- b) Capacity building through training;
- c) Procurement of common services to support the implementation of the CRV Network;
- d) Other support, as needed.

3. IMPLEMENTATION STRATEGY

3.1 The Parties, through the CRV OG will be agreed on which activities to undertake based on needs priority assessment. Upon determination, the decision will be communicated to TCB through the APAC Regional Office for execution, as appropriate.

3.2 In case the proposed activities exceed the available funds, TCB will communicate this to the Parties through the Regional Office. At this point, the parties will need to decide to either reduce scope of activities, inject additional funds and/or a combination thereof.

4. BUDGET

4.1 The detailed budget is as attached at Appendix A.

4.2 Funds will be equally shared among the Civil Aviation Authorities and/or related ANSPs that have signed the MSA and continue to be party to this Revision, and provided by them in advance of commencement of the project.

4.3 The total estimated amount is of US\$ 88,000 as per Appendix A. This amount is the total estimated amount including administrative and technical support.

5. RISK ASSESSMENT

5.1 Delay in the signing of this project document.

Risk Level: Medium

Mitigation: ICAO will work through the APAC Regional Office to facilitate the signing of the Project Document Revision B.

6. PROJECT MONITORING, REVIEW AND REPORTING

6.1 Monitoring activities

6.1.1 The overall implementation of the project is monitored through regular reporting and project review meetings as appropriate.

6.1.2 ICAO will execute and monitor the project in close consultation with the focal point designated by each Party.

6.1.3 ICAO will maintain the financial accounting and budgetary control of the project, in accordance with its policies and practices.

6.1.4 ICAO may carry out missions on site to monitor the progress of the project, in accordance with the approved work plan or as required.

6.2 ICAO roles and responsibilities include:

- a) to execute and monitor the project under the direction of the Director, TCB. The Director, TCB will delegate the responsibility for the monitoring/oversight of project activities to the appropriate level within the designated/nominated representatives of the Parties;
- b) to provide financial management and budgetary control in accordance with its policies, rules, practices, processes and procedures;
- c) briefing of personnel;
- d) administering ICAO experts' contracts;
- e) to provide financial statements in accordance with ICAO policies, rules, practices, processes and procedures;
- f) organizing experts' travel to duty station;
- g) formalizing acceptance of the completed project deliverables;
- h) revising the project document (PRODOC) as requested;
- i) formalizing all activities required to close the project.

This Project Document is not intended and should not be construed as a recognition or endorsement by ICAO of any functions and/or responsibilities entrusted to or performed by regional entities.

7 PROJECT RULES AND REGULATIONS

7.1 International experts/personnel

7.1.2 ICAO will recruit and deploy international experts/personnel in accordance with ICAO policies, practices, ICAO/TCB Field Staff Services Rules and applicable process and procedures. In particular, as consultants engaged by ICAO, their entitlement payments will be issued by ICAO. The lead-time required for the recruitment of the experts may range between six (6) weeks to three (3) months, from the moment the funds are committed until the deployment of the experts. In the eventuality of a contract extension being required for one or more ICAO expert(s), the Implementing Agency will need to issue the necessary request at least three (3) months prior to the end of the ICAO expert(s)' contract, subject to availability of funds; the request will include a justification and corresponding additional duration, as appropriate.

7.2 Procurement

7.1.1 The procurement of equipment or services are carried out in accordance with ICAO's Procurement Code, Financial Regulations and Rules, and applicable process and procedures.

7.2 Finance

7.2.1 The reception and management of funds for this project are subject to ICAO's Financial Regulations and Rules, and applicable process and procedures. The use of any of the resources for this project will be processed upon reception of proper formal authorization.

7.2.2 The unauthorized use of project resources is not allowed and could result in project delay and the discontinuation of the project's activities.

7.2.3 The provision of financial management and budgetary control of the project and submitting financial reports will be in accordance with ICAO rules, regulations, process and procedures.

7.2.4 ICAO will provide the financial statements concerning the services covered by this document, indicating the status of the funds, in US dollars. Any clarification or discrepancy with the financial statements must be officially communicated to ICAO within 30 days of receiving them, after which they are deemed accepted by the Parties.

7.2.5 If additional information is required after the deadlines set in the previous paragraph, costs related to such information will be charged to the project, with prior approval from the Parties.

7.3 General regulations

7.3.1 All project's activities are managed in accordance with the applicable ICAO policies, rules, regulations, processes and practices and applicable process and procedures.

7.3.2 Project activities, including reports and/or deliverables prepared by the ICAO experts may be reviewed by ICAO Headquarters and/or Regional Office, as appropriate.

7.3.3 This document was developed in English by the parties. Any document related to the implementation of this project that is required to be translated into another official language of ICAO, as may be required, shall be performed by ICAO and charged to the project, as appropriate. Any document related to the implementation of this project that is required to be translated into any other language not an official language of ICAO, shall be translated independently by that Party at its own cost. In case of disagreements on the text of any of the documents, the prevailing version will be the text in the original English language.

8 LEGAL FRAMEWORK

8.1 This project document shall constitute Revision B to Annex 1 (RAS14801) to the Management Service Agreement between the Parties.

8.2 The Project Document Revision B will come into force upon its signing by the Parties.

8.3 Any change, amendment or revision to this Project Document Revision (including scope, duration, budget, responsibilities, or other), will need to be formally approved in writing by the Parties.

8.4 Nothing contained in or relating to this Project Document Revision B shall be deemed a waiver, express or implied, of any of the privileges and immunities of ICAO and its personnel.

9 LIABILITY

9.1 The Parties shall indemnify, defend, and hold and save harmless, ICAO and its

officials, agents and employees, from and against all suits, proceedings, claims, demands, losses, and liability of any kind or nature brought against ICAO, including, but not limited to, all litigation costs and expenses, attorney's fees, settlement payments, and damages. For the avoidance of doubt, the Parties shall be obligated, at their sole expense, to defend ICAO and its officials, agents, and employees, regardless of whether the suits, proceedings, claims, and demands in question actually give rise to or otherwise result in any loss or liability.

9.2 ICAO shall advise the Parties about any such suits, proceedings, claims, demands, losses, or liability within a reasonable period of time after having received actual notice thereof. ICAO shall have control over any assertion or defense of the privileges and immunities of ICAO or any matter relating thereto, including the assertion or defense that ICAO is acting as mandatory for the Parties, for which only ICAO itself is authorized to assert and maintain. ICAO shall have the right to be represented in any such suit, proceeding, claim or demand by independent counsel of its own choosing and shall also be indemnified, held, and saved harmless by the Parties for such litigation costs and expenses and attorney's fees.

9.3 ICAO shall have the right to set-off any costs incurred pursuant to this Article from any remaining funds received under this Agreement.

9.4 The obligation under this clause shall survive the termination of this Agreement.

APPENDIX A

PROJECT BUDGET COVERING MSA CONTRIBUTION (IN UNITED STATES DOLLARS)

COUNTRY: REGIONAL PROJECT
PROJECT NO: RAS14801
PROJECT TITLE: COMMON REGIONAL VIRTUAL PRIVATE NETWORK (CRV) APAC
WORK ORDER: RAS14801-01
VERSION: 3

	TOTAL		2022		2023		2024		2025		2026	
	w/m	\$	w/m	\$	w/m	\$	w/m	\$	w/m	\$	w/m	\$
PROJECT PERSONNEL												
INTERNATIONAL PROFESSIONAL POSTS												
11.501 CONSULTANCIES AND CONTRACTORS (TSS FEE)		35 000		5 000		10 000		10 000		10 000		
SUB-TOTAL (INTERNATIONAL PROFESSIONAL POSTS)		35 000		5 000		10 000		10 000		10 000		
16.001 INTERNATIONAL TRAVEL		11 000		2 000		2 000		2 000		3 000		2 000
TOTAL (PROJECT PERSONNEL)		46 000		7 000		12 000		12 000		13 000		2 000
EQUIPMENT												
41.001 EXPENDABLE EQUIPMENT - INTERNATIONAL		30 000		10 000		20 000						
TOTAL (EQUIPMENT)		30 000		10 000		20 000						
MISCELLANEOUS												
51.001 REPORTING COSTS		2 200										2 200
52.001 MISCELLANEOUS EXPENSES		2 000		500		800		300		300		400
B807F PROFESSIONAL LIABILITY INSURANCE												
53.001 OVERHEAD CHARGES		7 500		2 100		2 700		1 200		1 300		200
TOTAL (MISCELLANEOUS)		12 000		2 600		3 500		1 500		1 600		2 800
PROJECT TOTAL		88 000		19 600		35 500		13 500		14 600		4 800



INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA AND PACIFIC OFFICE

AFTN/ATSMHS ROUTING DIRECTORY

ASIA AND PACIFIC REGIONS

Appendix B of the CNS SG/26 Report

September 2022

PREPARED BY THE ICAO ASIA AND PACIFIC REGIONAL OFFICE

EXPLANATORY NOTES

Regions. The Routing Directory is based on the existing AFTN circuits in the Asia and Pacific

I. Explanation of columns:

- a) Column A contains destination AFTN routing indicators. These indicators employ the minimum number of characters to preclude ambiguity.
- b) Columns 1, 2, 3 etc. contain the location indicators of the originating/relaying AFTN COM centres/stations in the heading and the AFTN routing indicators in conjunction with the destination indicators.
- c) Primary Routing is indicated in the left-hand subdivision under each origin, in upper case letters.
- d) Alternate routing is indicated in the right-hand subdivision under each origin, in lower case letters.
- e) National and/or non-AFTN routing is indicated by the letter (N). Local arrangement for alternate routing is indicated by the letter n.

II. Explanation of Symbols:

- A stations - stations in the "A" Aeronautical Fixed Service
Routing Area (AFSRA) - Solomon Is., Nauru,
and Papua New Guinea.
- AG stations - stations in Solomon Is.
- AN stations - stations in Nauru
- AY stations - stations in Papua New Guinea

- B stations - stations in the "B" AFSRA - (Greenland, Iceland)
- C stations - stations in the "C" AFSRA - (Canada)
- D stations - stations in the "D" AFSRA - (West Africa)
- E stations - stations in the "E" AFSRA - (Europe)
- F stations - stations in the "F" AFSRA - (Central and South Africa)
- G stations - stations in the "G" AFSRA - (Coastal West Africa)

- H stations - stations in the "H" AFSRA - (Coastal East Africa)
- HE stations - stations in the Arab Republic of Egypt

- K stations - stations in the "K" AFSRA - (U.S.A.)
- L stations - stations in the "L" AFSRA - (Europe, Mediterranean)
- M stations - stations in the "M" AFSRA - (Caribbean, Central America)

2.

N stations - stations in the "N" AFSRA (South Pacific)
 NC stations - stations in Cook Is.
 NF stations - stations in Fiji
 NFT stations - stations in Tonga
 NG stations - stations in Kiribati
 NGF stations - stations in Tuvalu
 NI stations - stations in Niue Island
 NL stations - stations in Futuna and Wallis Islands
 NS stations - stations in Samoa
 NST stations - stations in American Samoa
 NT stations - stations in French Polynesia
 NV stations - stations in Vanuatu
 NW stations - stations in New Caledonia
 NZ stations - stations in New Zealand

O stations - stations in the "O" AFSRA - (Middle East)
 OA stations - stations in Afghanistan
 OB stations - stations in Bahrain
 OE stations - stations in Saudi Arabia
 OI stations - stations in Iran, Islamic Rep. of
 OJ stations - stations in Jordan
 OK stations - stations in Kuwait
 OL stations - stations in Lebanon
 OM stations - stations in United Arab Emirates
 OO stations - stations in Oman
 OP stations - stations in Pakistan
 OR stations - stations in Iraq
 OS stations - stations in Syria
 OT stations - stations in Qatar
 OY stations - stations in Yemen

P stations - stations in the "P" AFSRA - (North Pacific)
 PA stations - stations in Alaska
 PB stations - stations in Baker Is.
 PC stations - stations in Phoenix Is.
 PG stations - stations in Mariana Is. Guam
 PH stations - stations in Hawaii
 PJ stations - stations in Johnston Is.
 PK stations - stations in Marshall Is.
 PL stations - stations in Line Is.
 PM stations - stations in Midway Is.
 PT stations - stations in Federated State of Micronesia
 PW stations - stations in Wake Is.

R stations - stations in the "R" AFSRA - (West Pacific)
 RC stations - stations in China
 RJ stations - stations in Japan
 RK stations - stations in Republic of Korea
 RO stations - stations in Japan (Ryukyu Is.)
 RP stations - stations in the Philippines

3.

S	stations - stations in the "S" AFSRA - (South America)
SA	stations - stations in Argentina
SC	stations - stations in Chile
T	stations - stations in the "T" AFSRA - (North East Caribbean)
U	stations - stations in the "U" AFSRA - (Russian Federation)
UT	stations - stations in Uzbekistan
V	stations - stations in the "V" AFSRA - (East and West Asia)
VA	stations - stations in India (West)
VC	stations - stations in Sri Lanka
VD	stations - stations in Cambodia
VE	stations - stations in India (East)
VG	stations - stations in Bangladesh
VH	stations - stations in Hong Kong
VI	stations - stations in India (North)
VL	stations - stations in Lao People's Democratic Republic
VM	stations - stations in Macau
VN	stations - stations in Nepal
VO	stations - stations in India (South)
VQ	stations - stations in Bhutan
VR	stations - stations in Maldives
VT	stations - stations in Thailand
VV	stations - stations in Viet Nam
VY	stations - stations in Myanmar
W	stations - stations in the "W" AFSRA (Brunei, Indonesia, Malaysia, Singapore, Southern South East Asia)
WA	stations - stations in Indonesia (Eastern part of Indonesia)
WB	stations - stations in Malaysia (East)
WBA	stations - stations in Brunei
WBS	stations - stations in Brunei
WI	stations - stations in Indonesia (Western part of Indonesia)
WM	stations - stations in Malaysia (West)
WP	stations - stations in Timor Leste
WR	stations - stations in Indonesia (Middle part of Indonesia)
WS	stations - stations in Singapore
Y	stations - stations in "Y" AFSRA (Australia)
Z	stations - stations in the "Z" AFSRA (China, Dem. People's Rep. of Korea, Mongolia)
Z	stations (except ZK and ZM) - stations in China
ZK	stations - stations in Democratic People's Republic of Korea
ZM	stations - stations in Mongolia

Note 1: The names of the continents, areas and countries appearing in parentheses indicate broadly the geographical location of the AFSRAs. The chart contained in Doc 7910, shows the delineation of these AFSRAs.

4.

AMENDMENTS

RECORD OF AMENDMENTS AND CORRIGENDA
RELATING TO AFTN ROUTING DIRECTORY, ASIA AND PACIFIC REGIONS,
TWENTY-SEVENTH EDITION

[illegible][illegible]

5.

A	1		2		3		4		5		6	
ORIGIN DESTINATION	AGGG		ANAU		AYPM		KSLC		NCRG		NFFN	
AG	(N)	n	YB		YB		YB	nf	NZ		YB	ks
AN	YB		(N)	n	YB		YB	nf	NZ		YB	ks
AY	YB		YB		(N)	n	YB	nf	NZ		YB	ks
B	YB		YB		YB		(N)	n	NZ		KS	yb
C	YB		YB		YB		(N)	n	NZ		KS	yb
D	YB		YB		YB		(N)	n	NZ		YB	ks
E	YB		YB		YB		(N)	n	NZ		YB	ks
F	YB		YB		YB		(N)	n	NZ		YB	ks
G	YB		YB		YB		(N)	n	NZ		YB	ks
H	YB		YB		YB		(N)	n	NZ		YB	ks
K	YB		YB		YB		(N)	n	NZ		KS	yb
L	YB		YB		YB		(N)	n	NZ		YB	ks
M	YB		YB		YB		(N)	n	NZ		KS	yb
NC	YB		YB		YB		NZ	yb	(N)	n	YB	ks
NF (EX. NFT)	YB		YB		YB		NF	yb	NZ		(N)	n
NFT	YB		YB		YB		NZ	yb	NZ		YB	ks
NG (EX. NGF)	YB		YB		YB		NF	yb	NZ		NGT	n
NGF	YB		YB		YB		NF	yb	NZ		NGF	n
NI	YB		YB		YB		NZ	yb	NZ		YB	ks
NL	YB		YB		YB		NF	yb	NZ		NW	n
NS (EX. NST)	YB		YB		YB		NZ	yb	NZ		YB	ks
NST	YB		YB		YB		NST	n	NZ		KS	yb
NT	YB		YB		YB		NZ	yb	NZ		YB	ks
NV	YB		YB		YB		YB	nf	NZ		YB	ks
NW	YB		YB		YB		NF	yb	NZ		NW	yb
NZ	YB		YB		YB		NZ	yb	NZ		YB	ks
OA	YB		YB		YB		(N)	n	NZ		YB	ks
OB	YB		YB		YB		(N)	n	NZ		YB	ks
OE	YB		YB		YB		(N)	n	NZ		YB	ks
OI	YB		YB		YB		(N)	n	NZ		YB	ks
OJ	YB		YB		YB		(N)	n	NZ		YB	ks
OK	YB		YB		YB		(N)	n	NZ		YB	ks
OL	YB		YB		YB		(N)	n	NZ		YB	ks
OM	YB		YB		YB		(N)	n	NZ		YB	ks
OO	YB		YB		YB		(N)	n	NZ		YB	ks
OP	YB		YB		YB		RJ	yb	NZ		YB	ks
OR	YB		YB		YB		(N)	n	NZ		YB	ks
OS	YB		YB		YB		(N)	n	NZ		YB	ks
OT	YB		YB		YB		(N)	n	NZ		YB	ks
OY	YB		YB		YB		(N)	n	NZ		YB	ks
P	YB		YB		YB		(N)	n	NZ		KS	yb
RC	YB		YB		YB		RJ	yb	NZ		YB	ks
RJ,RO	YB		YB		YB		RJ	yb	NZ		YB	ks
RK	YB		YB		YB		RJ	yb	NZ		YB	ks
RP	YB		YB		YB		RP	rj	NZ		YB	ks
S	YB		YB		YB		(N)	n	NZ		KS	yb
T	YB		YB		YB		(N)	n	NZ		KS	yb

[illegible]

7.

A	1		2		3		4		5		6	
ORIGIN DESTINATION	NFTF		NGFU		NGTT		NIUE		NSFA		NSTU	
AG	NZ		NF		NF		NZ		NZ		KS	
AN	NZ		NF		NF		NZ		NZ		KS	
AY	NZ		NF		NF		NZ		NZ		KS	
B	NZ		NF		NF		NZ		NZ		KS	
C	NZ		NF		NF		NZ		NZ		KS	
D	NZ		NF		NF		NZ		NZ		KS	
E	NZ		NF		NF		NZ		NZ		KS	
F	NZ		NF		NF		NZ		NZ		KS	
G	NZ		NF		NF		NZ		NZ		KS	
H	NZ		NF		NF		NZ		NZ		KS	
K	NZ		NF		NF		NZ		NZ		KS	
L	NZ		NF		NF		NZ		NZ		KS	
M	NZ		NF		NF		NZ		NZ		KS	
NC	NZ		NF		NF		NZ		NZ		KS	
NF (EX. NFT)	NZ		NF		NF		NZ		NZ		KS	
NFT	(N)	n	NF		NF		NZ		NZ		KS	
NG (EX. NGF)	NZ		NF		(N)	n	NZ		NZ		KS	
NGF	NZ		(N)	n	NF		NZ		NZ		KS	
NI	NZ		NF		NF		(N)	n	NZ		KS	
NL	NZ		NF		NF		NZ		NZ		KS	
NS (EX. NST)	NZ		NF		NF		NZ		(N)	n	KS	
NST	NZ		NF		NF		NZ		NZ		(N)	n
NT	NZ		NF		NF		NZ		NZ		KS	
NV	NZ		NF		NF		NZ		NZ		KS	
NW	NZ		NF		NF		NZ		NZ		KS	
NZ	NZ		NF		NF		NZ		NZ		KS	
OA	NZ		NF		NF		NZ		NZ		KS	
OB	NZ		NF		NF		NZ		NZ		KS	
OE	NZ		NF		NF		NZ		NZ		KS	
OI	NZ		NF		NF		NZ		NZ		KS	
OJ	NZ		NF		NF		NZ		NZ		KS	
OK	NZ		NF		NF		NZ		NZ		KS	
OL	NZ		NF		NF		NZ		NZ		KS	
OM	NZ		NF		NF		NZ		NZ		KS	
OO	NZ		NF		NF		NZ		NZ		KS	
OP	NZ		NF		NF		NZ		NZ		KS	
OR	NZ		NF		NF		NZ		NZ		KS	
OS	NZ		NF		NF		NZ		NZ		KS	
OT	NZ		NF		NF		NZ		NZ		KS	
OY	NZ		NF		NF		NZ		NZ		KS	
P	NZ		NF		NF		NZ		NZ		KS	
RC	NZ		NF		NF		NZ		NZ		KS	
RJ,RO	NZ		NF		NF		NZ		NZ		KS	
RK	NZ		NF		NF		NZ		NZ		KS	
RP	NZ		NF		NF		NZ		NZ		KS	
S	NZ		NF		NF		NZ		NZ		KS	
T	NZ		NF		NF		NZ		NZ		KS	

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	NTAA		NVVV		NWWW		NZCH		OPKC		PKMJ	
AG	NZ		YB		NF		YB	ks	VA	zb	KS	
AN	NZ		YB		NF		YB	ks	VA	zb	KS	
AY	NZ		YB		NF		YB	ks	VA	zb	KS	
B	NZ		YB		NF		KS	yb	OK	oi	KS	
C	NZ		YB		NF		KS	yb	OK	oi	KS	
D	NZ		YB		NF		YB	ks	OK	oi	KS	
E	NZ		YB		NF		YB	ks	OK	oi	KS	
F	NZ		YB		NF		YB	ks	OK	oi	KS	
G	NZ		YB		NF		YB	ks	OK	oi	KS	
H	NZ		YB		NF		YB	ks	OK	oi	KS	
K	NZ		YB		NF		KS	yb	OK	oi	KS	
L	NZ		YB		NF		YB	ks	OK	oi	KS	
M	NZ		YB		NF		KS	yb	OK	zb	KS	
NC	NZ		YB		NF		NC	n	VA	zb	KS	
NF (EX. NFT)	NZ		YB		NF		YB	ks	VA	zb	KS	
NFT	NZ		YB		NF		NFT	n	VA	zb	KS	
NG (EX. NGF)	NZ		YB		NF		YB	ks	VA	zb	KS	
NGF	NZ		YB		NF		YB	ks	VA	zb	KS	
NI	NZ		YB		NF		NI	n	VA	zb	KS	
NL	NZ		YB		NL		YB	ks	VA	zb	KS	
NS (EX. NST)	NZ		YB		NF		NS	n	VA	zb	KS	
NST	NZ		YB		NF		KS	yb	VA	zb	KS	
NT	(N)	n	YB		NF	nt	NT	n	VA	zb	KS	
NV	NZ		(N)	n	NF		YB	ks	VA	zb	KS	
NW	NZ	nw	YB		(N)	n	YB	ks	VA	zb	KS	
NZ	NZ		YB		NF		(N)	n	VA	zb	KS	
OA	NZ		YB		NF		YB	ks	OA	oi	KS	
OB	NZ		YB		NF		YB	ks	OK	oi	KS	
OE	NZ		YB		NF		YB	ks	OK	oi	KS	
OI	NZ		YB		NF		YB	ks	OI	ok	KS	
OJ	NZ		YB		NF		YB	ks	OK	oi	KS	
OK	NZ		YB		NF		YB	ks	OK	oi	KS	
OL	NZ		YB		NF		YB	ks	OK	oi	KS	
OM	NZ		YB		NF		YB	ks	OK	oi	KS	
OO	NZ		YB		NF		YB	ks	OK	oi	KS	
OP	NZ		YB		NF		YB	ks	(N)	n	KS	
OR	NZ		YB		NF		YB	ks	OI	ok	KS	
OS	NZ		YB		NF		YB	ks	OI	ok	KS	
OT	NZ		YB		NF		YB	ks	OK	oi	KS	
OY	NZ		YB		NF		YB	ks	OK	oi	KS	
P	NZ		YB		NF		KS	yb	VA	zb	(N)	n
RC	NZ		YB		NF		YB	ks	VA	zb	KS	
RJ,RO	NZ		YB		NF		YB	ks	VA	zb	KS	
RK	NZ		YB		NF		YB	ks	VA	zb	KS	
RP	NZ		YB		NF		YB	ks	VA	zb	KS	
S	NZ		YB		NF		KS	yb	OK	oi	KS	
T	NZ		YB		NF		KS	yb	OK	oi	KS	

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	PTKK		PTPN		PTRO		PTSA		PTYA		RCTP	
AG	KS		KS		KS		KS		KS		RP	vh
AN	KS		KS		KS		KS		KS		RP	vh
AY	KS		KS		KS		KS		KS		RP	vh
B	KS		KS		KS		KS		KS		VH	rp
C	KS		KS		KS		KS		KS		VH	rp
D	KS		KS		KS		KS		KS		RP	vh
E	KS		KS		KS		KS		KS		VH	rp
F	KS		KS		KS		KS		KS		RP	vh
G	KS		KS		KS		KS		KS		RP	vh
H	KS		KS		KS		KS		KS		RP	vh
K	KS		KS		KS		KS		KS		VH	rp
L	KS		KS		KS		KS		KS		VH	rp
M	KS		KS		KS		KS		KS		VH	rp
NC	KS		KS		KS		KS		KS		RP	vh
NF (EX. NFT)	KS		KS		KS		KS		KS		RP	vh
NFT	KS		KS		KS		KS		KS		RP	vh
NG (EX. NGF)	KS		KS		KS		KS		KS		RP	vh
NGF	KS		KS		KS		KS		KS		RP	vh
NI	KS		KS		KS		KS		KS		RP	vh
NL	KS		KS		KS		KS		KS		RP	vh
NS (EX. NST)	KS		KS		KS		KS		KS		RP	vh
NST	KS		KS		KS		KS		KS		RP	vh
NT	KS		KS		KS		KS		KS		RP	vh
NV	KS		KS		KS		KS		KS		RP	vh
NW	KS		KS		KS		KS		KS		RP	vh
NZ	KS		KS		KS		KS		KS		RP	vh
OA	KS		KS		KS		KS		KS		RP	vh
OB	KS		KS		KS		KS		KS		RP	vh
OE	KS		KS		KS		KS		KS		RP	vh
OI	KS		KS		KS		KS		KS		RP	vh
OJ	KS		KS		KS		KS		KS		RP	vh
OK	KS		KS		KS		KS		KS		RP	vh
OL	KS		KS		KS		KS		KS		RP	vh
OM	KS		KS		KS		KS		KS		RP	vh
OO	KS		KS		KS		KS		KS		RP	vh
OP	KS		KS		KS		KS		KS		RP	vh
OR	KS		KS		KS		KS		KS		RP	vh
OS	KS		KS		KS		KS		KS		RP	vh
OT	KS		KS		KS		KS		KS		RP	vh
OY	KS		KS		KS		KS		KS		RP	vh
P	(N)		(N)		(N)		(N)		(N)		VH	rp
RC	KS		KS		KS		KS		KS		(N)	n
RJ,RO	KS		KS		KS		KS		KS		RJ	vh
RK	KS		KS		KS		KS		KS		RJ	vh
RP	KS		KS		KS		KS		KS		RP	vh
S	KS		KS		KS		KS		KS		VH	rp
T	KS		KS		KS		KS		KS		VH	rp

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	RJJJ		RKSS		RPLL		UH HH		UUUU		VABB	
AG	WS	vh	RJ		WS	vh	UU	zb	RJ	n	VT	vc
AN	WS	vh	RJ		WS	vh	UU	zb	RJ	n	VT	vc
AY	WS	vh	RJ		WS	vh	UU	zb	RJ	n	VT	vc
B	KS	ws	RJ		VH	ws	UU	zb	BI	n	VT	vc
C	KS	ws	RJ		KS	vh	UU	zb	EG	n	VT	vc
D	WS	vh	RJ		WS	vh	UU	zb	LF	n	HK	vt
E	WS	vh	RJ		VH	ws	UU	zb	(N)	n	VT	vc
F	WS	vh	RJ		WS	vh	UU	zb	LF	n	HK	vt
G	WS	vh	RJ		WS	vh	UU	zb	LE	n	HK	vt
H	WS	vh	RJ		WS	vh	UU	zb	LG	n	HK	vt
K	KS	ws	RJ	zb	KS	vh	UU	zb	RJ	n	VT	vc
L	WS	vh	RJ		VH	ws	UU	zb	(N)	n	VT	vc
M	KS	ws	RJ		KS	vh	UU	zb	EG	n	VT	vc
NC	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NF (EX. NFT)	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NFT	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NG (EX. NGF)	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NGF	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NI	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NL	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NS (EX. NST)	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NST	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NT	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NV	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NW	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
NZ	KS	ws	RJ		WS	vh	UU	zb	RJ	n	VT	vc
OA	WS	vh	RJ		WS	vh	UU	n	LC	n	OP	vn
OB	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OE	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OI	WS	vh	RJ		WS	vh	UU	n	LC	n	OP	oo
OJ	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OK	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OL	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OM	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OO	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OP	WS	vh	RJ		WS	vh	UU	n	LC	n	OP	oo
OR	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OS	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OT	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
OY	WS	vh	RJ		WS	vh	UU	n	LC	n	OO	op
P	KS	ws	RJ		KS	vh	UU	zb	EG	n	VT	vc
RC	RC	vh	RJ		RC	vh	UU	zb	RJ	n	VT	vc
RJ,RO	(N)	n	RJ	zb	VH	rc	UU	zb	RJ	n	VT	vc
RK	RK	zb	(N)	n	VH	rc	UU	zb	RJ	n	VT	vc
RP	WS	vh	RJ		(N)	n	UU	zb	RJ	n	VT	vc
S	KS	ws	RJ		KS	vh	UU	zb	LE	n	VT	vc
T	KS	ws	RJ		KS	vh	UU	zb	EG	n	VT	vc

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	VCCC		VDPP		VECC		VGHS		VHHH		VIDD	
AG	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
AN	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
AY	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
B	WS	va	VT		VA	vg	VT	va	RJ	vt	VA	n
C	WS	va	VT		VA	vg	VT	va	RJ	rp	VA	n
D	WS	va	VT		VA	n	VT	va	VT	vvt	VA	n
E	WS	va	VT		VA	n	VT	va	VT	rj	VA	n
F	WS	va	VT		VA	vo	VT	va	VT	rp	VA	ve
G	WS	va	VT		VA	n	VT	va	VT	vvt	VA	n
H	WS	va	VT		VA	n	VT	va	VT	vvt	VA	n
K	WS	va	VT		VA	vg	VT	va	RJ	rp	VA	n
L	WS	va	VT		VA	n	VT	va	VT	rj	VA	n
M	WS	va	VT		VA	vg	VT	va	RJ	rp	VA	n
NC	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NF (EX. NFT)	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NFT	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NG (EX. NGF)	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NGF	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NI	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NL	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NS (EX. NST)	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NST	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NT	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NV	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NW	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
NZ	WS	va	VT		VA	vg	VT	va	VT	rp	VA	n
OA	VA	ws	VT		VA	n	VT	va	ZB	vt	VA	n
OB	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OE	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OI	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OJ	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OK	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OL	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OM	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OO	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OP	VA	ws	VT		VA	n	VT	va	ZB	vt	VA	n
OR	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OS	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OT	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
OY	WS	va	VT		VA	n	VT	va	VT	rp	VA	n
P	WS	va	VT		VA	vg	VT	va	RJ	rp	VA	n
RC	WS	va	VT		VA	vg	VT	va	RC	rp	VA	n
RJ,RO	WS	va	VT		VA	vg	VT	va	RJ	rc	VA	n
RK	WS	va	VT		VA	vg	VT	va	RJ	zb	VA	n
RP	WS	va	VT		VA	vg	VT	va	RP	rc	VA	n
S	WS	va	VT		VA	vg	VT	va	RJ	rp	VA	n
T	WS	va	VT		VA	vg	VT	va	RJ	rp	VA	n

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	VLVT		VMMC		VNKT		VOMM		VQPR		VRMM	
AG	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
AN	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
AY	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
B	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
C	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
D	VT	vv	VH	zg	ZB	va	VA	wm	VA		VC	
E	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
F	VT	vv	VH	zg	ZB	va	VA	wm	VA		VC	
G	VT	vv	VH	zg	ZB	va	VA	wm	VA		VC	
H	VT	vv	VH	zg	ZB	va	VA	wm	VA		VC	
K	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
L	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
M	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
NC	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NF (EX. NFT)	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NFT	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NG (EX. NGF)	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NGF	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NI	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NL	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NS (EX. NST)	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NST	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NT	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NV	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NW	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
NZ	VT	vv	VH	zg	VA	zb	WM	va	VA		VC	
OA	VT	vv	VH	zg	VA	zb	VA	n	VA		VC	
OB	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OE	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OI	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OJ	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OK	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OL	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OM	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OO	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OP	VT	vv	VH	zg	ZB	va	VA	wm	VA		VC	
OR	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OS	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OT	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
OY	VT	vv	VH	zg	VA	zb	VA	wm	VA		VC	
P	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
RC	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
RJ,RO	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
RK	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
RP	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
S	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	
T	VT	vv	VH	zg	ZB	va	WM	va	VA		VC	

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	VTBB		VVTs		VVVV		VYYY		WBKK		WBSB	
AG	WS	wm	VT	vh	VVT		VT		WM		WS	wm
AN	WS	wm	VT	vh	VVT		VT		WM		WS	wm
AY	WS	wm	VT	vh	VVT		VT		WM		WS	wm
B	VH	ws	VH	vt	VVT		VT		WM		WS	wm
C	VH	ws	VH	vt	VVT		VT		WM		WS	wm
D	WS	va	VT	vh	VVT		VT		WM		WS	wm
E	LI	ws	VH	vt	VVT		VT		WM		WS	wm
F	WS	va	VT	vh	VVT		VT		WM		WS	wm
G	WS	va	VT	vh	VVT		VT		WM		WS	wm
H	WS	va	VT	vh	VVT		VT		WM		WS	wm
K	VH	ws	VH	vt	VVT		VT		WM		WS	wm
L	LI	ws	VH	vt	VVT		VT		WM		WS	wm
M	VH	ws	VH	vt	VVT		VT		WM		WS	wm
NC	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NF (EX. NFT)	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NFT	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NG (EX. NGF)	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NGF	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NI	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NL	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NS (EX. NST)	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NST	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NT	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NV	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NW	WS	wm	VT	vh	VVT		VT		WM		WS	wm
NZ	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OA	VA	ws	VT	vh	VVT		VT		WM		WS	wm
OB	WS	va	VT	vh	VVT		VT		WM		WS	wm
OE	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OI	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OJ	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OK	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OL	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OM	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OO	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OP	VA	ws	VT	vh	VVT		VT		WM		WS	wm
OR	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OS	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OT	WS	wm	VT	vh	VVT		VT		WM		WS	wm
OY	WS	wm	VT	vh	VVT		VT		WM		WS	wm
P	VH	ws	VH	vt	VVT		VT		WM		WS	wm
RC	VH	ws	VH	vt	VVT		VT		WM		WS	wm
RJ,RO	VH	ws	VH	vt	VVT		VT		WM		WS	wm
RK	VH	ws	VH	vt	VVT		VT		WM		WS	wm
RP	VH	ws	RP	vh	VVT		VT		WM		WS	wm
S	VH	ws	VH	vt	VVT		VT		WM		WS	wm
T	VH	ws	VH	vt	VVT		VT		WM		WS	wm

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	WIII		WMKK		WPDL		WSSS		YBBB		ZBBB	
AG	YB	ws	WS	vt	Y		YB	wi	AG	n	RJ	zg
AN	YB	ws	WS	vt	Y		YB	wi	AN	n	RJ	zg
AY	YB	ws	WS	vt	Y		YB	wi	AY	n	RJ	zg
B	YB	ws	WS	vt	Y		RJ	yb	KS	nf	RJ	zg
C	YB	ws	WS	vt	Y		RJ	yb	KS	nf	RJ	zg
D	YB	ws	WS	vt	Y		YB	vt	FA	ws	RJ	op
E	WS	yb	WS	vt	Y		EG	vt	WS	wi	RJ	zg
F	YB	ws	WS	vt	Y		YB	vt	FA	ws	RJ	op
G	YB	ws	WS	vt	Y		YB	vt	FA	ws	RJ	op
H	YB	ws	WS	vt	Y		YB	vt	FA	ws	RJ	op
K	YB	ws	WS	vt	Y		RJ	yb	KS	nf	RJ	zg
L	WS	yb	WS	vt	Y		EG	vt	WS	wi	RJ	zg
M	YB	ws	WS	vt	Y		RJ	yb	KS	nf	RJ	zg
NC	YB	ws	WS	vt	Y		YB	wi	NZ	ks	RJ	zg
NF (EX. NFT)	YB	ws	WS	vt	Y		YB	wi	NF	nz	RJ	zg
NFT	YB	ws	WS	vt	Y		YB	wi	NZ	ks	RJ	zg
NG (EX. NGF)	YB	ws	WS	vt	Y		YB	wi	NF	nz	RJ	zg
NGF	YB	ws	WS	vt	Y		YB	wi	NF	nz	RJ	zg
NI	YB	ws	WS	vt	Y		YB	wi	NZ	ks	RJ	zg
NL	YB	ws	WS	vt	Y		YB	wi	NF	nz	RJ	zg
NS (EX. NST)	YB	ws	WS	vt	Y		YB	wi	NZ	ks	RJ	zg
NST	YB	ws	WS	vt	Y		YB	wi	KS	nf	RJ	zg
NT	YB	ws	WS	vt	Y		YB	wi	NZ	ks	RJ	zg
NV	YB	ws	WS	vt	Y		YB	wi	NV	n	RJ	zg
NW	YB	ws	WS	vt	Y		YB	wi	NF	nz	RJ	zg
NZ	YB	ws	WS	vt	Y		YB	wi	NZ	ks	RJ	zg
OA	WS	yb	VO	vt	Y		VC	vt	WS	wi	OP	vn
OB	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OE	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OI	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OJ	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OK	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OL	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OM	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OO	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OP	WS	yb	VT	ws	Y		VT	oo	WS	wi	OP	zg
OR	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OS	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OT	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
OY	WS	yb	WS	vt	Y		OB	vt	WS	wi	OP	zg
P	YB	ws	WS	vt	Y		RJ	yb	KS	nf	RJ	zg
RC	WS	yb	WS	vt	Y		RJ	vt	WS	wi	RJ	zg
RJ,RO	WS	yb	WS	vt	Y		RJ	vt	WS	wi	RJ	zg
RK	WS	yb	WS	vt	Y		RJ	vt	WS	wi	RK	rj
RP	WS	yb	WS	vt	Y		RP	vt	WS	wi	VH	zg
S	YB	ws	WS	vt	Y		RJ	yb	KS	nf	RJ	zg
T	WS	yb	WS	vt	Y		RJ	yb	KS	nf	RJ	zg

[illegible]

A	1		2		3		4		5		6	
ORIGIN DESTINATION	ZGGG		ZJHK		ZKKK		ZMUB					
AG	VH	zb	VH	zg	ZB	n	ZB					
AN	VH	zb	VH	zg	ZB	n	ZB					
AY	VH	zb	VH	zg	ZB	n	ZB					
B	ZB	vh	ZG	vh	ZB	n	ZB					
C	ZB	vh	ZG	vh	ZB	n	ZB					
D	ZB	vh	ZG	vh	ZB	n	ZB					
E	VH	zb	VH	zg	ZB	n	ZB					
F	ZB	vh	VH	zg	ZB	n	ZB					
G	ZB	vh	ZG	vh	ZB	n	ZB					
H	ZB	vh	ZG	vh	ZB	n	ZB					
K	ZB	vh	ZG	vh	RK	zb	ZB					
L	VH	zb	VH	zg	ZB	n	ZB					
M	ZB	vh	ZG	vh	ZB	n	ZB					
NC	VH	zb	VH	zg	ZB	n	ZB					
NF (EX. NFT)	VH	zb	VH	zg	ZB	n	ZB					
NFT	VH	zb	VH	zg	ZB	n	ZB					
NG (EX. NGF)	VH	zb	VH	zg	ZB	n	ZB					
NGF	VH	zb	VH	zg	ZB	n	ZB					
NI	VH	zb	VH	zg	ZB	n	ZB					
NL	VH	zb	VH	zg	ZB	n	ZB					
NS (EX. NST)	VH	zb	VH	zg	ZB	n	ZB					
NST	VH	zb	VH	zg	ZB	n	ZB					
NT	VH	zb	VH	zg	ZB	n	ZB					
NV	VH	zb	VH	zg	ZB	n	ZB					
NW	VH	zb	VH	zg	ZB	n	ZB					
NZ	VH	zb	VH	zg	ZB	n	ZB					
OA	ZB	vh	ZG	vh	ZB	n	ZB					
OB	ZB	vh	ZG	vh	ZB	n	ZB					
OE	ZB	vh	ZG	vh	ZB	n	ZB					
OI	ZB	vh	ZG	vh	ZB	n	ZB					
OJ	ZB	vh	ZG	vh	ZB	n	ZB					
OK	ZB	vh	ZG	vh	ZB	n	ZB					
OL	ZB	vh	ZG	vh	ZB	n	ZB					
OM	ZB	vh	ZG	vh	ZB	n	ZB					
OO	ZB	vh	ZG	vh	ZB	n	ZB					
OP	ZB	vh	ZG	vh	ZB	n	ZB					
OR	ZB	vh	ZG	vh	ZB	n	ZB					
OS	ZB	vh	ZG	vh	ZB	n	ZB					
OT	ZB	vh	ZG	vh	ZB	n	ZB					
OY	ZB	vh	ZG	vh	ZB	n	ZB					
P	ZB	vh	ZG	vh	ZB	n	ZB					
RC	ZB	vh	VH	zg	ZB	n	ZB					
RJ,RO	ZB	vh	ZG	vh	RK	zb	ZB					
RK	ZB	vh	ZG	vh	RK	zb	ZB					
RP	VH	zb	VH	zg	ZB	n	ZB					
S	ZB	vh	ZG	vh	ZB	n	ZB					
T	ZB	n	ZG	vh	ZB	n	ZB					

[illegible]

25.

A	1		2		3		4		5		6	
ORIGIN DESTINATION	ZGGG		ZJHK		ZKKK		ZMUB					

AFTN/ATSMHS CONNECTIONS - ASIA/PAC ROUTING DIRECTORY

Terminal I (^ - BBIS)	Terminal II	ATSMHS or AFTN	Over CRV (Y/N)
Apia/Faleolo	Christchurch	AMHS/UA	N
Bangkok^	Beijing	AMHS	N
	Dhaka	AMHS	N
	Ho-Chi-Minh	AFTN	N
	Hong Kong	AMHS	Y
	Kuala Lumpur	AMHS	N
	Mumbai	AMHS	N
	Paro	AMHS	Y
	Phnom Penh	AMHS	N
	Rome	AMHS	N
	Singapore	AMHS	N
	Vientiane	AMHS	N
	Yangon	AMHS	N
Beijing^	Bangkok	AMHS	N
	Fukuoka	AMHS	Y
	Guangzhou	AFTN	N
	Hong Kong	AMHS	Y
	Karachi	AFTN	N
	Khavarosk	AFTN	N
	Kathmandu	AFTN	N
	Mumbai	AMHS	N
	Pyongyang	AFTN	N
	Seoul	AMHS	N
	Ulaan Baatar	AFTN	N
	Yangon	AFTN	N
Brisbane^	Christchurch	AMHS	Y
	Honiara	AFTN/UA	N
	Jakarta	AFTN	N
	Johannesburg	AMHS	N
	Nadi	AMHS	Y
	Nauru	AFTN/UA	N
	Port Moresby	AFTN	Y
	Port Vila	AFTN/UA	N
	Salt Lake City	AMHS	Y
	Singapore	AMHS	Y
	Timor Leste	AFTN/UA	N
Brunei	Kuala Lumpur	AFTN	N
	Singapore	AFTN	N
Chennai	Mumbai	AFTN	N
	Kolkata	AFTN	N
	Kuala Lumpur	AFTN	N

Terminal I (^ - BBIS)	Terminal II	ATSMHS or AFTN	Over CRV (Y/N)
Christchurch	Apia/Faleolo	AMHS/UA	N
	Brisbane	AMHS	Y
	Niue	AMHS/UA	N
	Papeete/Tahiti	AFTN	N
	Rarotonga	AMHS/UA	N
	Salt Lake City	AMHS	Y
	Tonga/Fua'Amotu	AMHS/UA	N
Chuuk	Salt Lake City	AMHS/UA	N
Colombo	Mumbai	AMHS	N
	Male	AFTN	N
	Singapore	AFTN	N
Delhi	Kolkata	AFTN	N
	Mumbai	AFTN	N
	Tashkent-Uzhny	AFTN	N
Dhaka	Bangkok	AMHS	N
	Mumbai	AMHS	N
	Kolkata	AFTN	N
Fukuoka[^]	Beijing	AMHS	Y
	Hong Kong	AMHS	Y
	Moscow	AFTN	N
	Seoul	AFTN	N
	Singapore	AMHS	Y
	Salt Lake City	AMHS	Y
	Taipei	AMHS	Y
Guangzhou	Beijing	AFTN	N
	Hong Kong	AFTN	N
	Haikou	AFTN	N
	Hanoi	AFTN	N
	Macau	AFTN	N
Hanoi	Ho-Chi-Minh	AFTN	N
	Guangzhou	AFTN	N
	Vientiane	AFTN	N
Haikou	Guangzhou	AFTN	N
	Hong Kong	AFTN	N
Ho-Chi-Minh	Bangkok	AFTN	N
	Hanoi	AFTN	N
	Hong Kong	AFTN	N
	Singapore	AFTN	N
	Manila	AFTN	N

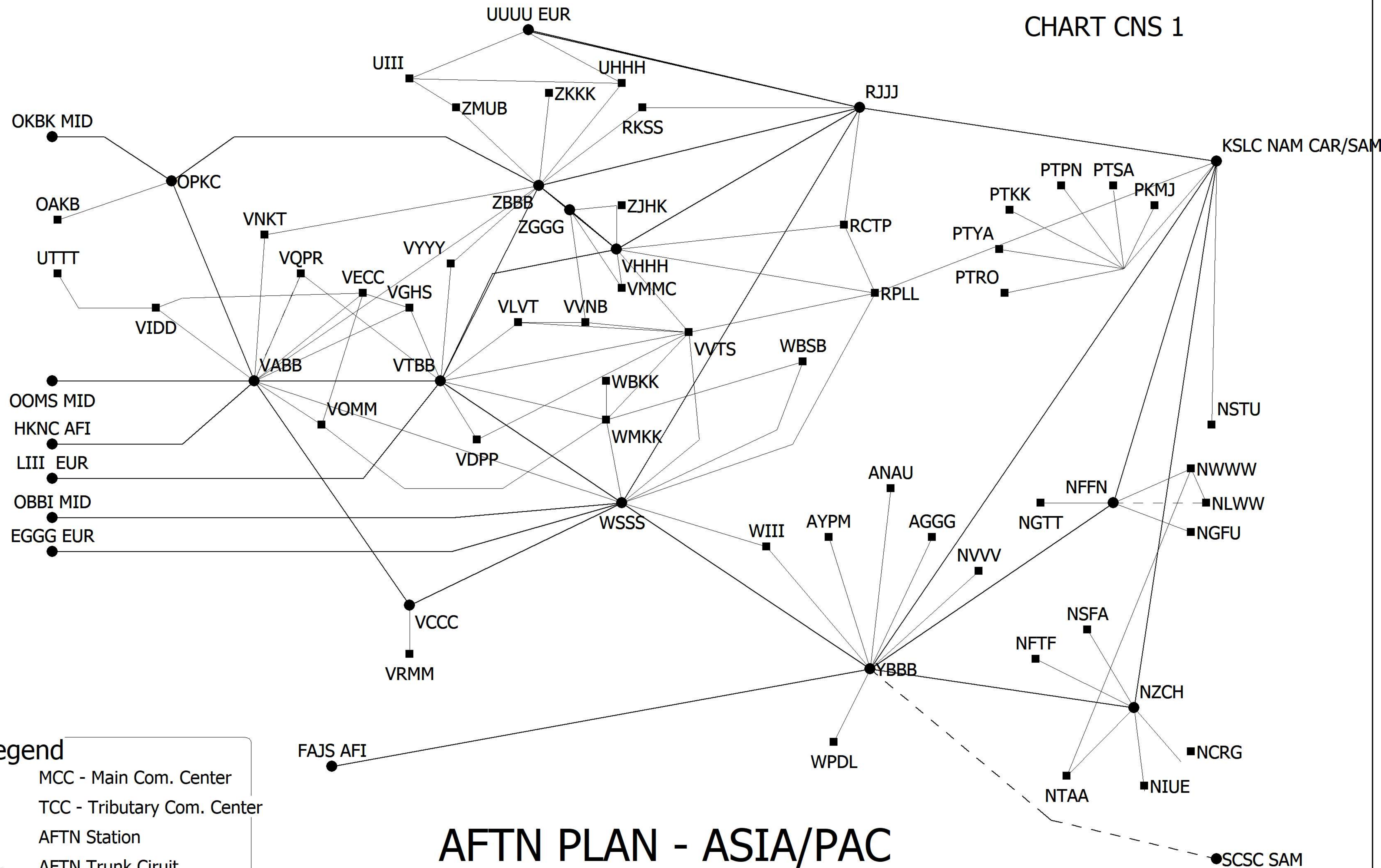
Terminal I (^ - BBIS)	Terminal II	ATSMHS or AFTN	Over CRV (Y/N)
	Phnom Penh	AFTN	N
	Kuala Lumpur	AFTN	N
	Vientiane	AFTN	N
Hong Kong[^]	Bangkok	AMHS	Y
	Beijing	AMHS	Y
	Fukuoka	AMHS	Y
	Guangzhou	AFTN	N
	Ho-Chi-Minh	AFTN	N
	Macau	AMHS	N
	Manila	AMHS	Y
	Haikou	AFTN	N
	Taipei	AMHS	Y
Honiara	Brisbane	AMHS/UA	N
Jakarta	Brisbane	AFTN	N
	Singapore	AMHS	N
Karachi	Beijing	AFTN	N
	Kabul	AFTN	N
	Kuwait	AMHS	N
	Mumbai	AMHS	N
	Tehran (<i>Not listed in the ANP AFTN Planning Table</i>)		
Kathmandu	Beijing	AFTN	N
	Mumbai	AMHS	N
Kolkata	Mumbai	AFTN	N
	Chennai	AFTN	N
	Delhi	AFTN	N
Koro	Salt Lake City	AMHS/UA	N
Kosrae	Salt Lake City	AMHS/UA	N
Kuala Lumpur	Bangkok	AFTN	N
	Brunei	AFTN	N
	Chennai	AFTN	N
	Singapore	AFTN	N
	Ho-Chi-Minh	AFTN	N
Macau	Guangzhou	AFTN	N
	Hong Kong	AMHS	N
Majuro	Salt Lake City	AMHS/UA	N
Male	Colombo	AFTN	N

Terminal I (^ - BBIS)	Terminal II	ATSMHS or AFTN	Over CRV (Y/N)
Manila	Hong Kong	AMHS	Y
	Ho Chi Minh	AFTN	N
	Singapore	AMHS	Y
	Salt Lake City	AMHS	Y
	Taipei	AMHS	Y
Mumbai^	Bangkok	AMHS	N
	Beijing	AMHS	N
	Chennai	AFTN	N
	Colombo	AMHS	N
	Delhi	AFTN	N
	Dhaka	AMHS	N
	Karachi	AMHS	N
	Kathmandu	AMHS	N
	Kolkata	AFTN	N
	Muscat/Seeb	AFTN (No connection)	N
	Nairobi	AFTN	N
	Paro	AMHS	N
	Singapore	AMHS	N
Nadi^	Brisbane	AMHS	Y
	Funafuti	AMHS/UA	N
	Noumea	AMHS	N
	Salt Lake City	AMHS	Y
	Tarawa	AMHS/UA	N
	Wallis Is.	AMHS/UA	N
Nauru	Brisbane	AMHS/UA	N
Niue	Christchurch	Email	N
Noumea	Nadi	AMHS	N
Pago Pago	Salt Lake City	AMHS/UA	N
Papeete/Tahiti	Christchurch	AFTN	N
Paro	Mumbai	AMHS	N
	Bangkok	AMHS	Y
Phnom Penh	Bangkok	AMHS	N
	Ho Chi Minh	AFTN	N
Pohnpei	Salt Lake City	AMHS/UA	N
Port Moresby	Brisbane	AFTN	Y
Port Vila	Brisbane	AMHS/UA	N
Pyongyang	Beijing	AFTN	N

Terminal I (^ - BBIS)	Terminal II	ATSMHS or AFTN	Over CRV (Y/N)
Rarotonga	Christchurch	AFTN	N
Salt Lake City^	Brisbane	AMHS	Y
	Christchurch	AMHS	Y
	Chuuk	AMHS UA	N
	Fukuoka	AMHS	Y
	Koro	AMHS UA	N
	Kosrae	AMHS UA	N
	Majuro	AMHS UA	N
	Manila	AMHS	Y
	Nadi	AMHS	Y
	Pago Pago	AMHS UA	N
	Pohnpei	AMHS UA	N
	Yap	AMHS UA	N
Seoul/Gimpo	Beijing	AMHS	N
	Fukuoka	AFTN	N
Singapore^	Bangkok	AMHS	N
	Bahrain	AFTN	N
	Brisbane	AMHS	Y
	Brunei	AFTN	N
	Colombo	AFTN	N
	Fukuoka	AMHS	Y
	Ho-Chi-Minh	AFTN	N
	Jakarta	AMHS	N
	Kuala Lumpur	AMHS	N
	London	AMHS	N
	Manila	AMHS	Y
	Mumbai	AMHS	N
Taipei	Hong Kong	AMHS	Y
	Fukuoka	AMHS	Y
	Manila	AMHS	Y
Tarawa	Nadi	AMHS/UA	N
Timor Leste/Dili	Brisbane	AMHS	N
Tonga/Fua'Amotu	Christchurch	AMHS/UA	N
Ulaan Baatar	Beijing	AFTN	N
	Irkutsk	AFTN	N
Vientiane	Bangkok	AMHS	N
	Hanoi	AFTN	N
	Ho-Chi-Minh	AFTN	N

Terminal I (^ - BBIS)	Terminal II	ATSMHS or AFTN	Over CRV (Y/N)
Wallist Is.	Nadi	(planning)	-
Yangon	Bangkok	AMHS	N
	Beijing	AFTN	N
Yap	Salt Lake City	AMHS/UA	N

CHART CNS 1



Legend

- MCC - Main Com. Center
- TCC - Tributary Com. Center
- AFTN Station
- AFTN Trunk Circuit
- AFTN Circuit
- Non_implemented Circuit

AFTN PLAN - ASIA/PAC

AMHS Readiness Report for Supporting IWXXM Traffic					
No.	States/Administration	Name of State (Administration)/name of BBIS/BIS location where AMHS is installed:	AFTN/AMHS transition date/schedule	Readiness Status of AMHS for supporting File Transfer Body Part (FTBP), the Interpersonal Message (IPM) Heading Extension (IHE) to support for exchanging IWXXM reports of a maximum size of 4MB and FTBP of maximum 2MB:	Capacity status of the operational AFS links to support the exchange of the required meteorological information in both IWXXM GML form and TAC form:
1	Australia	Airservices - Brisbane	Completed. AMHS exchange in place with USA, Fiji, New Zealand, Singapore and South Africa. AFTN still in place with Indonesia and PNG, migration to AMHS based on pending readiness both partners Several Pacific island nations connecting via FCO CADAS ATS Terminal, currently over AFTN. Airservices plans to migrate to AMHS P3 CADAS but will need to provide user training. All domestic users and data originators still on AFTN, no desire by external partners to migrate to AMHS, awaiting SWIM instead.	Full compliance and support since Nov 2020	Airservices has contracted a 2.0Mbps bandwidth using CRV Package C+ for Voice & AMHS services. Bandwidth on the leased line with South Africa / Johannesburg is also 2Mbps.
2	China	Beijing	AMHS deployed in 2008 which was upgraded to support ATN/IPS in 2013 and upgraded to support exchanging IWXXM in 2020.	support	CRV bandwidth is 3M. Minimally 64kbps for each AMHS connection..
3	Hong Kong China	Hong Kong China	December 2009	Support	2MB for CRV and 64kbps for IPLCs
4	Fiji	Fiji Airport/Air Traffic Management Centre	Completed. In June 2019, Fiji completed the transition of ATN BBIS to IPS for the AMHS service from Nadi to Salt Lake, USA & Brisbane, Australia over the CRV network. The local end User still operates on AFTN terminal and is converted to AMHS over the AFTN/AMHS Gateway.	The Comsoft AMHS System supports File Transfer Body Part (FTBP). Our system has the capability of exchanging IWXXM reports of a maximum size of 4MB and FTBP of maximum.	Nadi has contracted a 1.0Mbps bandwidth using CRV Package C+ for Voice & AMHS services. The total bandwidth usage for voice and data is 768K from the total 1.0Mbps. The bandwidth for AMHS is 64Kbps each to Brisbane & Salt Lake Center. It is noted in the ACSICG/7 WP04 presented by USA that 64Kbps is the minimum recommended required bandwidth for AMHS to exchange FTBP for IWXXM.
5	India	AAI/Mumbai Airport	AMHS is in operation since 2011. India is in the process of tendering for replacement of existing AMHS system . The Tender action stands delayed due to COVID pandemic.	Presently India is not able to exchange the required 4 MB messages and 2 MB FTBP attachments.	Indian Meteorological Department is in the process of upgradation of HPC & DB to support IWXXM.

CNS SG/26
Appendix C to the Report

No.	States/Administration	Name of State (Administration)/name of BBIS/BIS location where AMHS is installed:	AFTN/AMHS transition date/schedule	Readiness Status of AMHS for supporting File Transfer Body Part (FTBP), the Interpersonal Message (IPM) Heading Extension (IHE) to support for exchanging IWXXM reports of a maximum size of 4MB and FTBP of maximum 2MB:	Capacity status of the operational AFS links to support the exchange of the required meteorological information in both IWXXM GML form and TAC form:
6	Japan	Japan/Fukuoka	ATN BBIS router and AMHS installed at 2000. Connection tests with USA 2000 - 2004 and put into operational use in 2005 and over CRV in February 2019. Put into AMHS operation with Hong- Kong and Singapore in 2021. AMHS implementation with China in 2021 , Korea and Taipei in 2022.	Already support exchange of IWXXM messages based on FTBP in August 2015. It is possible to send , receive and transfer up to 2GB for the contents such as FTBP,IPM and IHE in AMHS,and the size of IWXXM supported system by Japan Meteorological Agency is 2MB	AFS links over CRV is a Package A, Bandwidth 2M.
7	Macao China	Macao China	Q4/2009	Q3/2021	To be determined
8	New Zealand	Airways – Christchurch	AMHS connections are in place with Australia, USA and the New	Support	Airways New Zealand has contracted a 1.0Mbps bandwidth using CRV Package C+ for Voice and AMHS services from Auckland and Christchurch.
9	Philippines	Philippines/ATMC Manila	Completed March 2018	Can support IHE and FTBP maximum 1MB (tested with Taipei on 13-May-20)	1MB Philippines has contracted 2Mbps bandwidth using CRV package “A” voice and data services.
10	Republic of Korea	Gimpo international airport	ATN/AMHS with China put into operational use in June, 2011. AMHS implementation with China and Japan over CRV will be in 4Q, 2022.	AMHS implementation for supporting FTBP and IHE will be in 4Q, 2022.	AFS links over CRV is a Package A, Bandwidth 2M.
11	Singapore	Singapore	March 2011	Yes	2MB for CRV and minimally 64kbps for IPLCs
12	Thailand	Thailand	BBIS/BIS Routers already implemented. AMHS has been implemented since July 2011. Connection with Bangladesh, Bhutan, Cambodia, China, India, Lao PDR, Myanmar, Singapore, Hong Kong China, and Malaysia implemented. Connection with SITA (SITA AMHS Gateway inter-connections) implemented. Bangkok - Vietnam Circuit	Completed, the IWXXM exchange has been implemented since November 2020.	The capacity of links readied to support in both form.

CNS SG/26
Appendix C to the Report

No.	States/Administration	Name of State (Administration)/name of BBIS/BIS location where AMHS is installed:	AFTN/AMHS transition date/schedule	Readiness Status of AMHS for supporting File Transfer Body Part (FTBP), the Interpersonal Message (IPM) Heading Extension (IHE) to support for exchanging IWXXM reports of a maximum size of 4MB and FTBP of maximum 2MB:	Capacity status of the operational AFS links to support the exchange of the required meteorological information in both IWXXM GML form and TAC form:
			IOT Test : Done POT Test: Planned for end of 3Q2021 Bangkok - Rome Circuit IOT Test: Planned for 3Q2021 POT Test: Planned for 4Q2021		
13	USA	Federal Aviation Administration	Q4, 2020	Yes. FAA AMHS has FTBP capability. National Weather Service (NWS) projected to implement IWXXM by Q3, 2021	Yes. 2MB bandwidth over CRV

Seamless ANS Plan v4.0

With reference to the expected publication of the ICAO PANS-Information Management (PANS-IM) in 2024 and the expected sunset date of the current flight plan format (FPL2012) of 2032 being considered by ICAO ATMRPP, the timeframe for SWIM implementation in Asia-Pacific region was set at between 2024 and 2030. The expectation is that Asia-Pacific States will be SWIM ready by 2030 and the intervening 2 years till the expected sunset date of 2032 of the FPL2012 format can be used to conduct FF-ICE related operational trials. The timeframe **was adopted** by APANPIRG/33 by the **Conclusion APANPIRG/33/ xx** (SWIM TF/06/02) - *The Asia-Pacific SWIM Implementation Timeframe*.

APANPIRG/33 also considered including SWIM implementation as part of Performance Improvement Plan in the next edition the Asia/Pacific Seamless ANS Plan aligned with SWIM implementation timeframe which was adopted by the **Conclusion APANPIRG/33/ xx** (SWIM TF/06/04): *Inclusion of the Asia/Pacific SWIM Implementation in the Asia/Pacific Seamless ANS Plan*.

Therefore, in order to ensure that SWIM, a key building block to achieve the vision outlined in the Global ATM Operational Concept (Doc 9854), is properly captured in the Asia/Pacific Seamless ANS Plan, following SWIM ASBUs are included for the year 2024. The elements required to be added from 2025 would be added in the fifth amendments of the plan in 2025.

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

TERMS OF REFERENCE

SWIM Task Force

Objectives: In order to achieve the SWIM thread as specified in the Aviation System Block Upgrade (ASBU) of the Global Air Navigation Plan (GANP), the Asia/Pacific Seamless ANS Plan objectives, and the air navigation systems that are in compliance with ICAO global standards for the conceptualisation and exchange of aeronautical, flight and meteorological information, the SWIM Task Force will:

- a) Benchmark the various successful implementations of SWIM in States and regions to promote best practices;
- b) Develop and maintain the Asia/Pacific regional roadmap for SWIM implementation, including SWIM technical infrastructure, SWIM governance, SWIM information services;
- c) Propose a high-level Asia/Pacific regional SWIM architecture, the corresponding SWIM technical infrastructure requirements, and the implementation approach to construct such architecture principally over CRV and other IP based networks to ensure interoperability among regional SWIM participants, to support transition for non-SWIM capable entities;
- d) Develop the Asia/Pacific regional SWIM cyber security architecture framework and SWIM security strategy in line with ICAO International Aviation Trust Framework (IATF);
- e) Support APANPIRG WGs/TFs regarding information exchange models and examine if any extension to the existing information exchange models, i.e. AIXM, FIXM, and IWXXM, and/or the new information exchange model(s) are required to support the Asia/Pacific regional operational requirements;
- f) Establish a robust and sustainable governance model to ensure that a common set of policies, rules, and standards for identifying, designing, implementing, discovering, and operating SWIM-enabling components, including SWIM registries, is consistently applied and enforced throughout the Asia/Pacific region;
- g) Develop and define the Asia/Pacific version of the SWIM information service overview specifications and the Asia/Pacific version of data catalogue for information services based on the regional operational needs;
- h) Track and observe SWIM demonstrations and trials within the Asia/Pacific region as well as provide, if required, support for regional SWIM demonstrations;
- i) Encourage and support interested APAC Member States to construct a platform for SWIM services and applications validation and to support the implementation of SWIM services and applications;
- j) Monitor developments by the IMP and escalate the regional issues as required;
- k) Identify, communicate, and liaise with relevant APANPIRG WGs/TFs in regard to SWIM-related activities, including providing support to refine SWIM operational and communications requirements;
- l) Develop an educational and promotional materials required to support the regional SWIM implementation to ensure cohesiveness among regional SWIM participants;

- m) Assist APAC Member States to implement the Asia/Pacific regional SWIM, as appropriate;; and
- n) Undertake any other approved tasks related to SWIM implementation that may arise in the future.

Composition:

The SWIM TF will consist of experts from ATM, AIM, MET, and CNS from Asia/Pacific States and international organizations such as IATA and ICCAIA.

Conduct of the work:

The task force will conduct its work through web conferences, teleconferences, other electronic means of communications, and Face-to-Face meetings.

Reporting:

The group will report to CNS SG.

**PROPOSED UPDATES TO
FLIGHT INSPECTION GUIDANCE MATERIAL
(SECOND EDITION)**

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

Page (vii) of Flight Inspection Guidance Material (Second Edition)

ABBREVIATIONS

DF	Direction Finder
DGPS	Differential Global Positioning System
UAS	Unmanned Aerial System

Page 2-12 of Flight Inspection Guidance Material (Second Edition)

2.5.3 During pandemic situation, every country may have different travel restriction policies in place to contain the spread of pandemic. Cross-country deployment of flight inspection may become difficult or infeasible due to border closure, especially for those States who do not have their own FISP. Therefore, States may have to consider to deploy flight inspection crew and aircraft to alternative base for timely completion of flight inspection. In this situation and to safeguard the health condition of flight inspection crew, the following considerations could be made when planning for the flight inspection:

- (a) Negotiate with the FISP in advance for performing flight inspection from alternative base where is classified as low risk of the epidemic situation;
- (b) Seek support from the government of the alternative base for the flight inspection activities;
- (c) Work with local government to apply for exemption permits for the FISP to enter States If deployment from alternative base in another country is not possible, either due to border closure or not practical. The States should cater ample time when applying such permits so to ensure all the systems and facilities still comply with the State's regulatory requirement on the periodicity of flight inspection;

- (d) Encourage FISP to develop a special management plan for performing flight inspection under pandemic as it may facilitate the exemption permits application in States. The pandemic management plan could include the following areas:
- (i) Hazard & risk management
 - (ii) Fitness for duty evaluation for FISP crew – daily body temperature & symptoms check records
 - (iii) Self-isolation requirements for FISP crew
 - (iv) Mask wearing, social distancing and personal hygiene requirements for FISP crew
 - (v) Incident reporting mechanism
 - (vi) Contact tracing documents - names / telephone of physical contacts with FISP crew
- (e) Develop special arrangements during the flight inspection period, for example:
- (i) Seek support from the relevant party to set up all essential ground equipment for flight inspection, e.g. DGPS equipment, locally and by local staff, instead of the flight inspection crew to be deployed;
 - (ii) Arrange point to point transportation between the airport and accommodation for the flight crew with close-loop arrangement as far as practicable;
 - (iii) Conduct virtual meeting with the FISP for coordination and discussion on the flight inspection reports to avoid face to face meetings;
 - (iv) Create controlled itinerary for the flight inspection crew, where the flight inspection crew is only allowed to leave their accommodation to carry out the flight inspection. This will minimize the physical interaction between the flight inspection crew and the public; and
 - (v) Keep up to date with the latest requirements of the exemption permits applied, e.g. the need for the flight inspection crew to take Polymerase Chain Reaction (PCR) tests during the flight inspection period and the maximum number of days the flight inspection crew is allowed to stay.
- (f) Such special/additional arrangements may incur extra cost for each deployment. The flight inspection crew might need to be quarantined upon return to the country where the FISP is based. States should consider these additional costs when planning for each deployment.

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3.2 OTHER TYPES OF FLIGHT INSPECTION

3.2.1 Procedure Validation

3.2.1.1 This is detailed in ICAO Doc 9906, Quality Assurance Manual for Flight Procedure Design. Volume 5 – Validation of Instrument Flight Procedures. The ANSP, FISP and Procedure Design Company need to work closely to ensure this aspect is covered off adequately.

3.2.2 Surveillance Flight Inspection

3.2.2.1 Surveillance flight inspection may be arranged for providing supplementary check and verification on the performance of the newly commissioned radio navigation aids, before its next required periodic flight inspection. Since the stability on operating environment and new system itself are yet to be demonstrated, the additional surveillance flight inspection could early detect any potential issues on system performance after commissioning and before the next routine check. Maintenance staff could then take prompt and appropriate actions to rectify the issues spotted to avoid safety hazards.

~~3.2.1~~3.2.3 VHF equipment, ADS-B, GBAS

~~3.2.2~~3.2.3.1 Flight inspection is typically carried out under request from an appropriately trained Communications/ADS-B or GBAS engineer. The specifics such as location, type of check and flight profiles are determined by a collaborative approach between all involved disciplines. In some cases, flight inspection is used to assist in the validation of models for determining coverage.

~~3.2.3~~3.2.4 Performance-based Navigation – RNAV and RNP

~~3.2.3~~3.2.4.1 At a minimum, the aircraft should have the capability to undertake the desired procedure validation. RNP procedures' validation requirements would normally be specified within the Procedure Design Company specifications. The Aeronautical Design and Development organization should analyze the results to determine containment within the specified criteria. Technical assessment perspective is as follows;

- (a) Validation of obstacle survey data is recommended during the flight validation process.
- (b) Verification of survey data can be performed by setting ground stations at certain survey points. The ground survey team can check and compare the DGPS signal to the TSO avionics aircraft receiver position.
- (c) The survey data may be affected by waypoint, track and bearing error.
- (d) The effect of terrain shielding should be taken into consideration.
- (e) Verification is often done slightly lower than the published profile to remove altimeter error as often it is advantageous to verify in the worst-case position.

3.3.1 Test Accuracy Ratios (TAR)

3.3.1.1 As the results obtained by the flight inspection system could potentially be used to defend a service provider in the event of an incident or accident, the State should clearly specify the standards adopted in the maintenance and calibration of the systems used for flight inspection purposes. To effectively perform calibration of a system, the calibration equipment should be typically ~~five~~ 5 times (minimum ~~three~~ 3 times) times more accurate than the system equipment. Some considerations should be as follows:

- (a) Temperature stability and compensation.
- (b) Electromagnetic interference.
- (c) Polar Pattern considerations.
- (d) Absolute measurements.
- (e) Relative measurements.
- (f) Aircraft receiver and calibration equipment duplication.

App-1 Appendix 1

1. USEFUL REFERENCE

- **ICASC Website**
<http://www.icasc.co>
- ICASC - Document on Standards and Recommended ~~Practises~~ **Practices** for Flight Inspection & Flight Validation Organisations
http://www.icasc.co/sites/faa/uploads/documents/Library/ICASC/ICASC_SARPs_FI_FV_v14_11102018_final101.pdf
- ICASC Recommended Flight Inspection & Flight Validation Contract Annex
http://www.icasc.co/sites/faa/uploads/documents/Library/ICASC/ICASC_FIS_Contract__Annex_v0_2_26_05_2016_final101.pdf
- Reference ~~Note note~~ from ICAO on the **Considerations** ~~considerations~~ of **Radio radio** ~~Navigation navigation~~ **Aids aids** ~~Flight flight~~ **Inspection inspection** ~~Periodicity periodicity~~
<https://www.icao.int/safety/OPS/OPS-Normal/Pages/Flight-inspection-for-radio-aids.aspx>

App-2 Appendix 2

1.2. Among the numerous requirements from the International Civil Aviation Organization (ICAO), flight navigation systems must be regularly calibrated, inspected and maintained to ensure that all essential navigation aids for pilots are always working properly. This means that these systems must be tuned and maintained to radiate the correct signals in the airspace, at any time. To achieve this, a combination of ground and air inspections is necessary, like the localizer measurements for CAT III ILS (~~Instrument Landing System~~).

1.3. ILS is an essential navigation aid to help pilots land their aircraft in low visibility conditions during IFR (~~Instrument Flight Rules~~) flights. In order to maintain the ICAO ILS certification, dynamic measurements need to be performed by the airport operators / ANSPs, their subcontracted flight inspection organizations or government agencies. These companies are always looking to improve and streamline inspection processes to mitigate impacts on airport operations. The regular ILS signal inspection is made in flight, using a manned aircraft. It requires prior coordination and preparation with

various stakeholders, together with ground measurements in order to optimize the manned flight inspection.

3.1. ~~As in 2019, f~~Flight inspection organizations or institutes in Belgium, China, Germany, Italy, Russia, Spain have used drones to assist and provide supplementary tests in flight inspection works. The drones are normally be used to assist testing of navigation equipment signals, since they are not competent for all flight inspection missions with limited performance in speed, service ceiling, endurance, crosswind resistance, payload, etc. Some latest developments on technology and standard shared by States/organizations are listed below for reference:

3.4. China

(a) In CNS/SG/25 meeting, China has shared their trials and application of UAS as well as the progress of standards development. Some reference materials contributed by China are summarized below for reference:

- i) UAS-Based PAPI Inspection Technology in China
https://www.icao.int/APAC/Meetings/2021%20CNS%20SG%2025/WP24_CHN%20AI.12%20-%20UAS-based%20PAPI%20Inspection%20Technology%20in%20China.pdf
- ii) Standard Establishment of UAS-Based Flight Inspection System in China
https://www.icao.int/APAC/Meetings/2021%20CNS%20SG%2025/Flimsy%2003_CHN%20AI.12%20-%20Standard%20establishment%20of%20UAS-based%20flight%20inspection%20system%20in%20China.pdf
- iii) Standard Establishment of Data Link for UAS-Based Flight Inspection in China
https://www.icao.int/APAC/Meetings/2021%20CNS%20SG%2025/IP15_CHN%20AI.12%20-%20Standard%20Establishment%20of%20Data%20Link%20for%20UAS-based%20Flight%20Inspection.pdf



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

**MODE S DOWNLINK AIRCRAFT PARAMETERS IMPLEMENTATION
AND OPERATIONS GUIDANCE DOCUMENT**

Edition 4.0 - August 2022

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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. The latest version (Edition 3.0) was adopted by CNS SG/25 in 2021. This version includes information related to ADS-B DAPs, and the revised draft is prepared and proposed to be endorsed by Mode S DAPs WG/5.

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

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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

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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 ~~in different versions, as the version 3 was published in December, 2020,~~ 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.

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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

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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 :			
8. DAPs IGD EDITOR		DATE REC'D :	
9. FEEDBACK PASSED		DATE :	

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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

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 Status
FTE	Flight Technical Error
HDG	Heading
HRD	Horizontal Reference Direction
GICB	Ground-Initiated Comm-B
GNSS	Global Navigation Satellite System
GVA	Geometric Vertical Accuracy
HMI	Human Machine Interface

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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

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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	

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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 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	To indicate common usage GICB services currently

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	Capability Report	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.

4.2 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	Magnetic Heading	To provide heading and speed data to

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	and Speed Report	Indicated Air Speed	ground systems.
		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.

4.3 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	
		Surveillance Status	
BDS code 0,6	Surface Position	Surface Position	To provide accurate surface position information.
		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	

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		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 Subtype 0	Aircraft Operational Status-While Airborne	Airborne Capability Class	To provide the capability class and current operational mode of ATC-related applications and other operational information.
		Airborne Operational Mode	
		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	

4.4 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	I021/040

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			message type (BDS Code 0,5 or 0,6)	
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.

4.5 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)

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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:

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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.

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- 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.

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- 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

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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.

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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 Appendix2 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

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- 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.

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- 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)
-

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- 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

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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

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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:

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- 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.

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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.

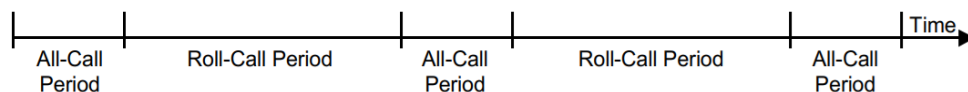


Figure.7-1 The Typical MIP

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.

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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.

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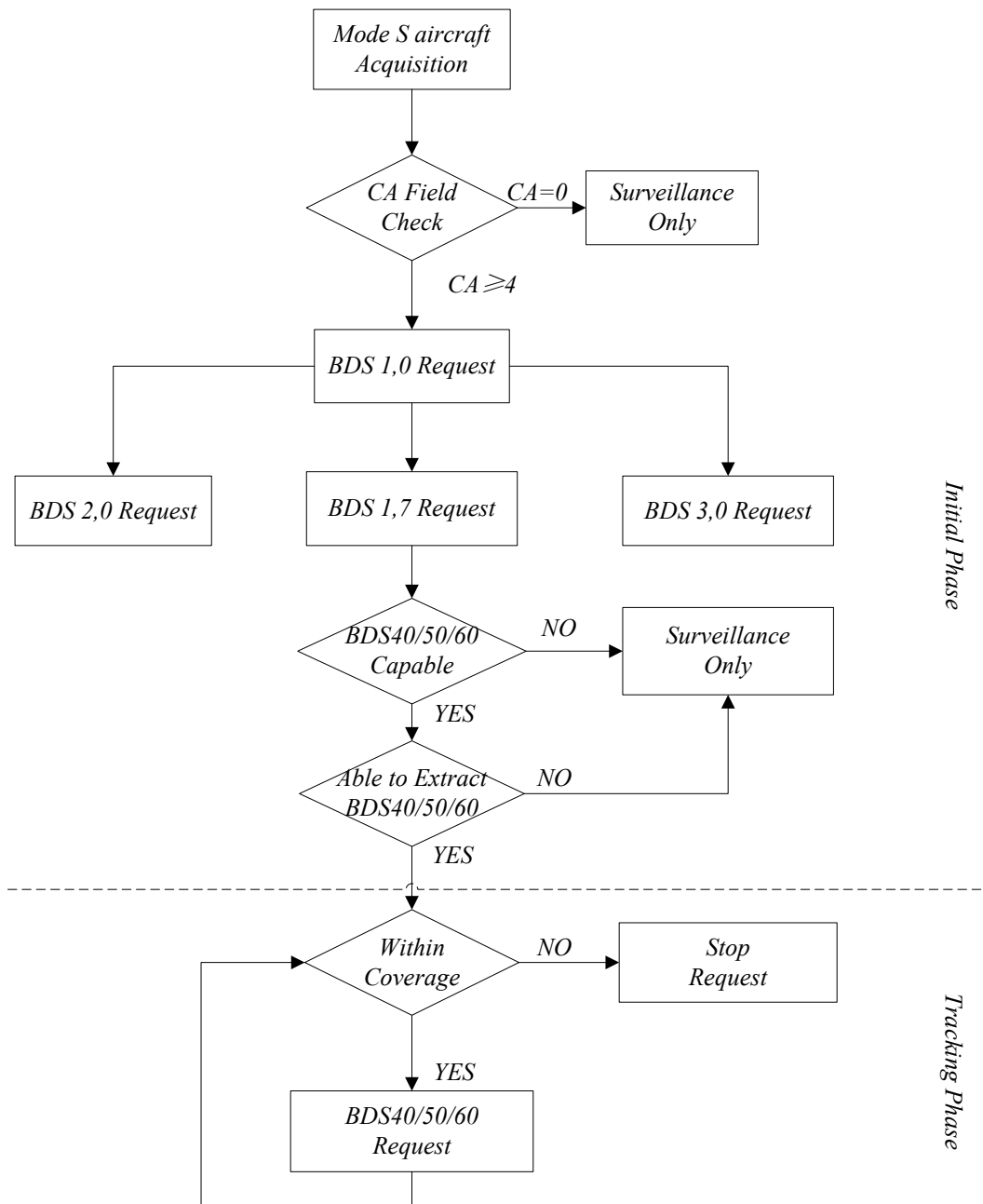


Figure.7-2 The Typical Procedure of DAPs Extraction

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

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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.

7.4 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

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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

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	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					
	-		Mode A Code						
	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		-				
			Subtype 0	Subtype 1					
	TCP+1 Data		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		-					

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		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	Surface 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

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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.

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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.

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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 analyze 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,

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-
- 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

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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:

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- 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:

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- 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

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		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).*

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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.

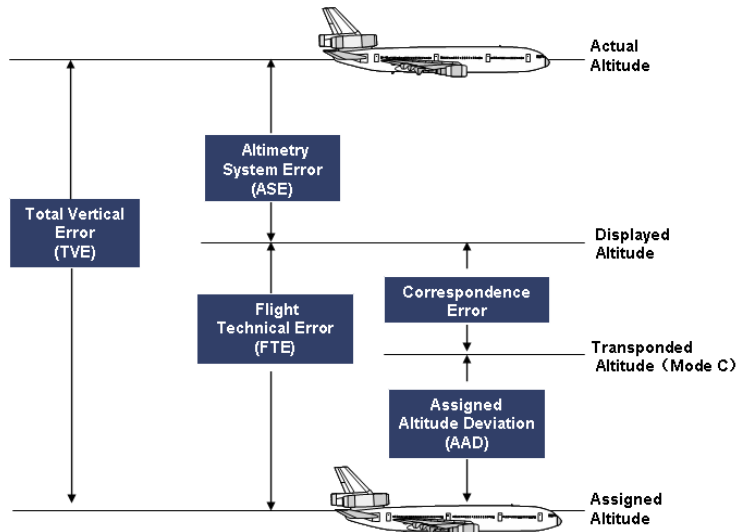


Figure 9-1: Relationship between the vertical errors

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.

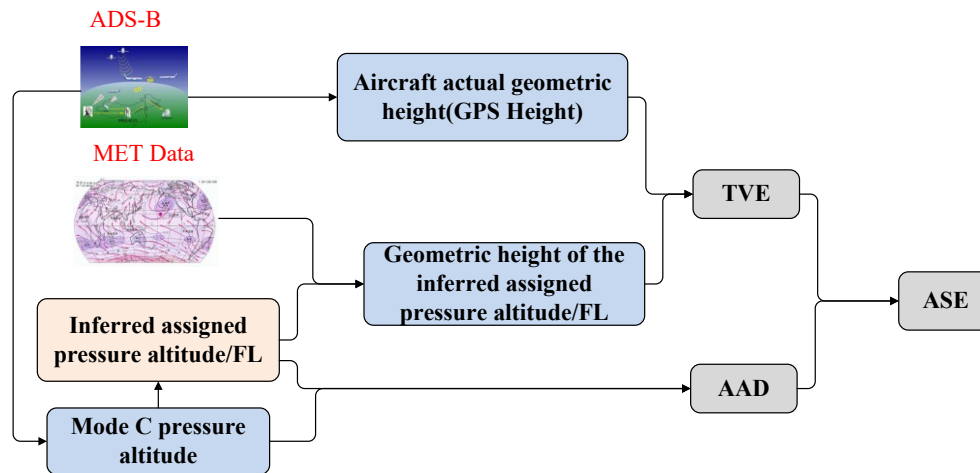


Figure 9-2: Calculation process of TVE, AAD and ASE based on ADS-B

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) $AAD \geq 90 \text{ m (300 ft)}$.

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.

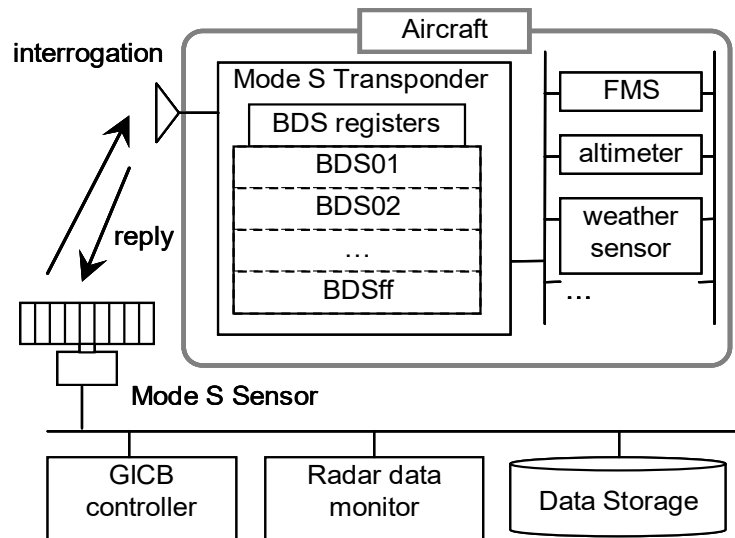


Figure1 - Example of Data Recording Configuration

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

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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

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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.

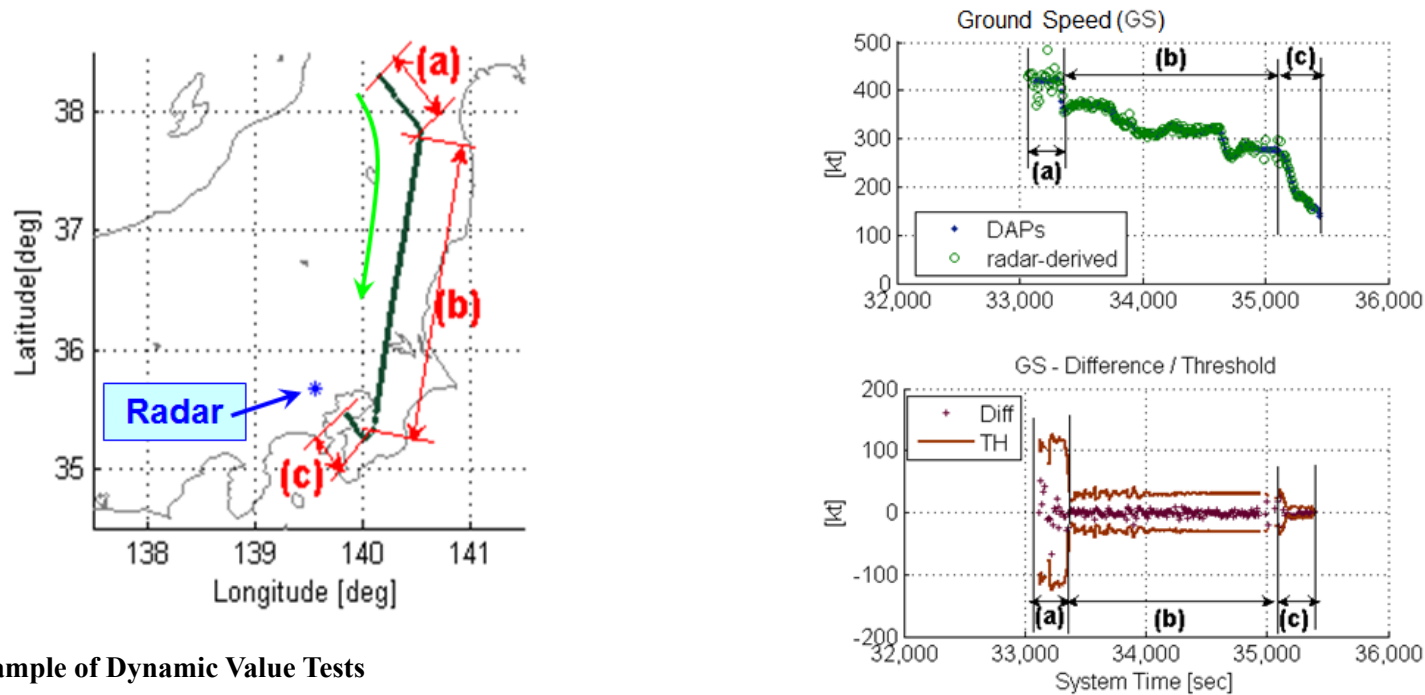


Figure 2 - Example of Dynamic Value Tests

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.

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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)

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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.	

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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.

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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

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	BDS 4,0	Selected Altitude (MCP/FCU)	2-13	ft	16	[0, 65520]
		Selected Altitude (FMS)	15-26	ft	16	[0, 65520]
		Barometric Pressure Setting	28-39	mb	0.1	[0, 410]

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BDS 5,0	Roll Angle	3-11	dg	45/256	[-90, +90]
	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]
BDS 6,0	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.

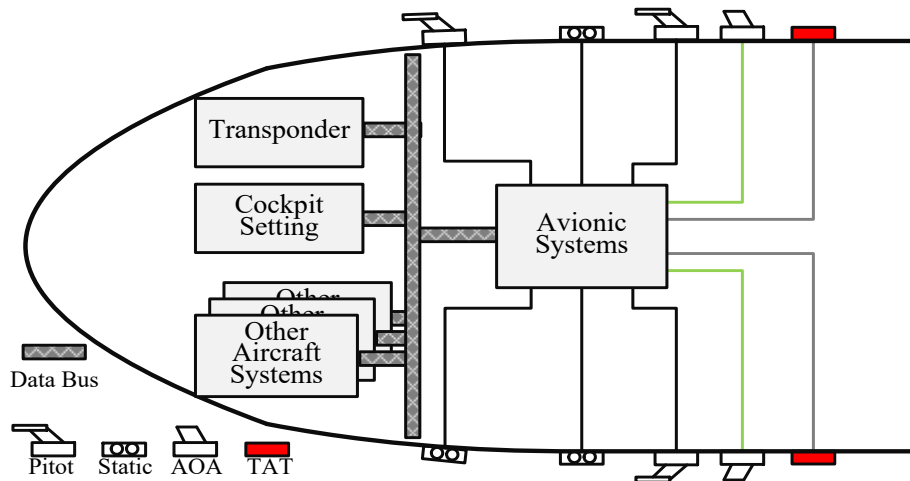


Figure 3.1 Typical DAPs Data Source Block Diagram

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).

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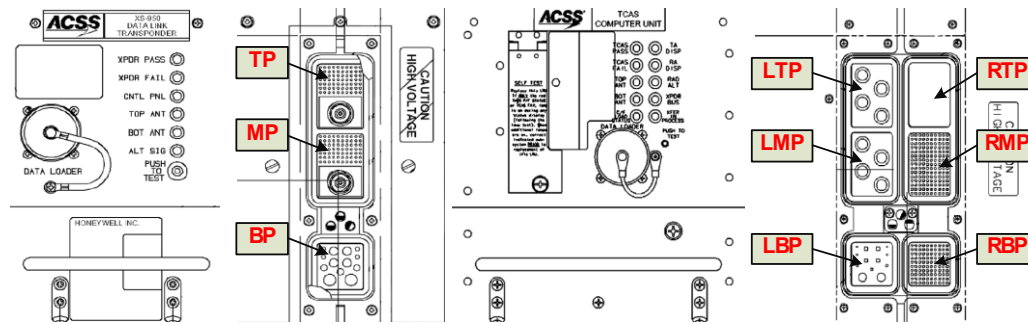


Figure 3.2 Transponder and TCAS Computer Examples from ACSS

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.

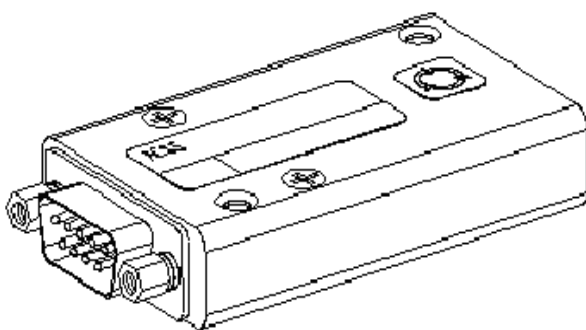


Figure 3.3 APM Example from ACSS

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.

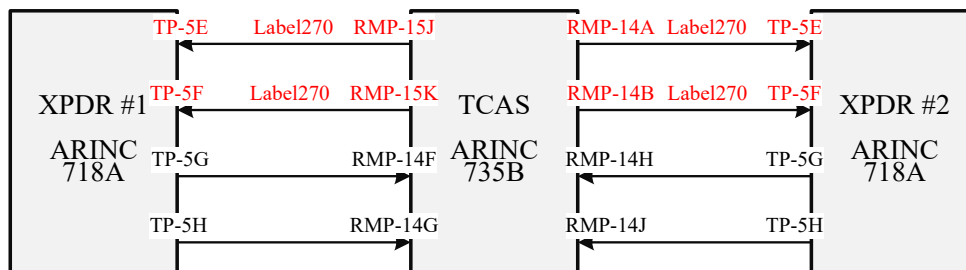


Figure 3.5 Illustrations of Datalink Capability and RA Report Transfer

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.

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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

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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.

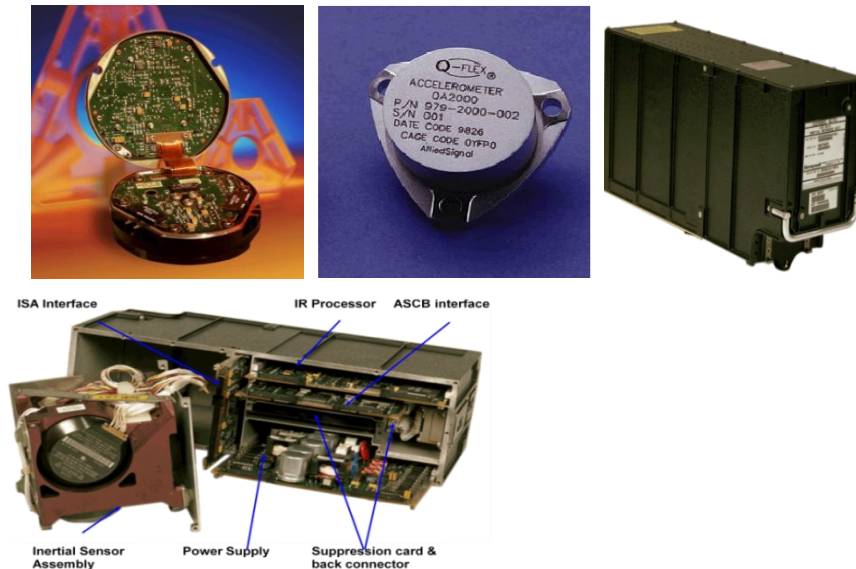


Figure 3.8 Gyro, Accelerometer and LASEREF IV IRU from Honeywell

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:

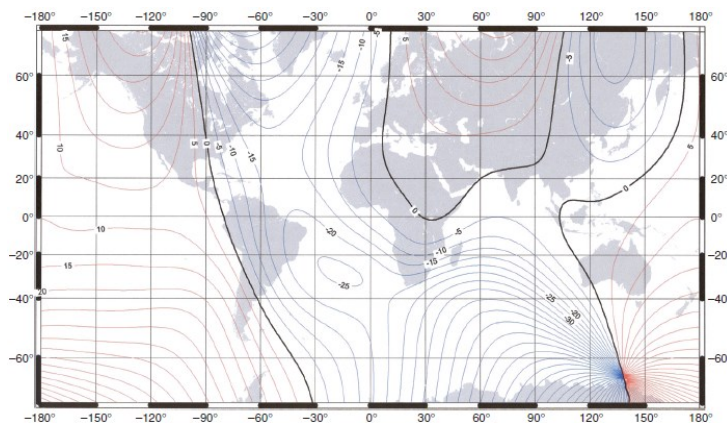


Figure 3.9 World Magnetic Model 2000

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.

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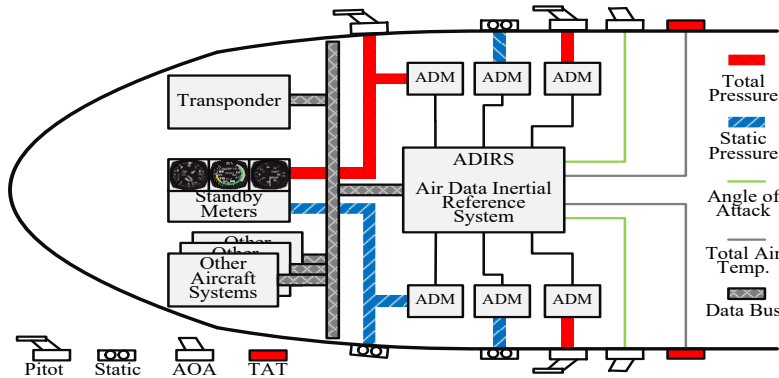


Figure 3.10 Typical ADIRS Architecture

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.

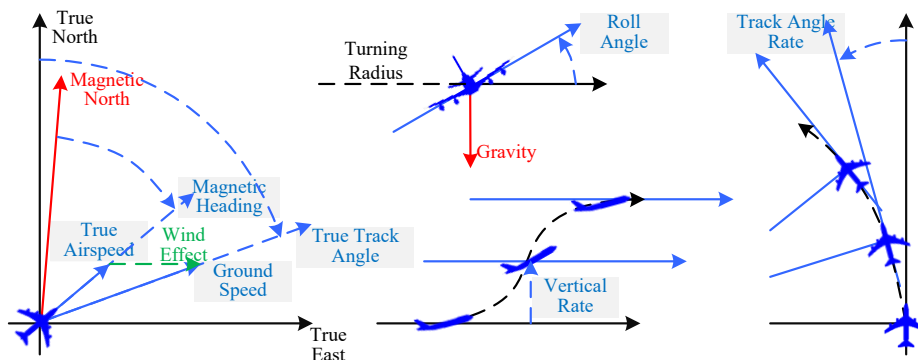
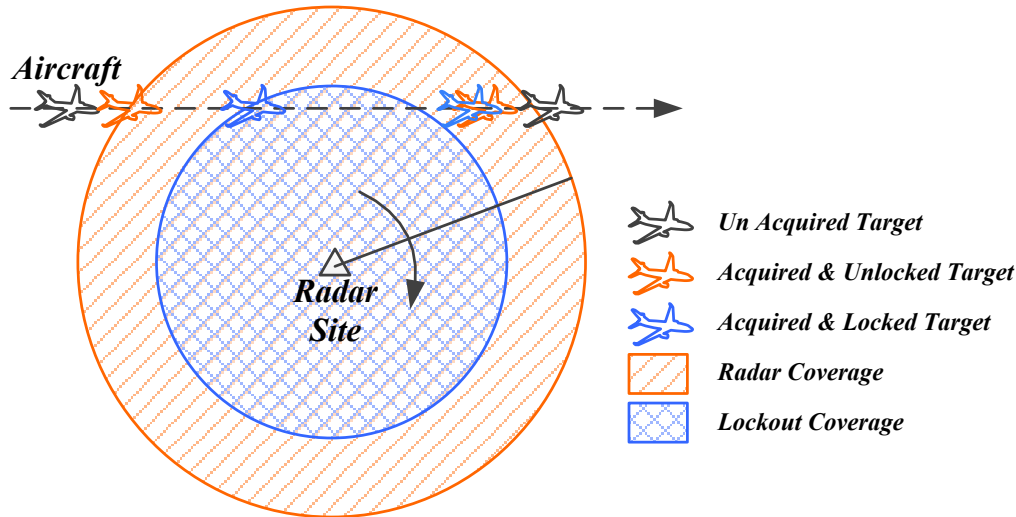


Figure 3.11 Illustration of Aircraft Dynamic

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:

$$T \geq \frac{R * 2 * 1852}{3 * 10^8}$$

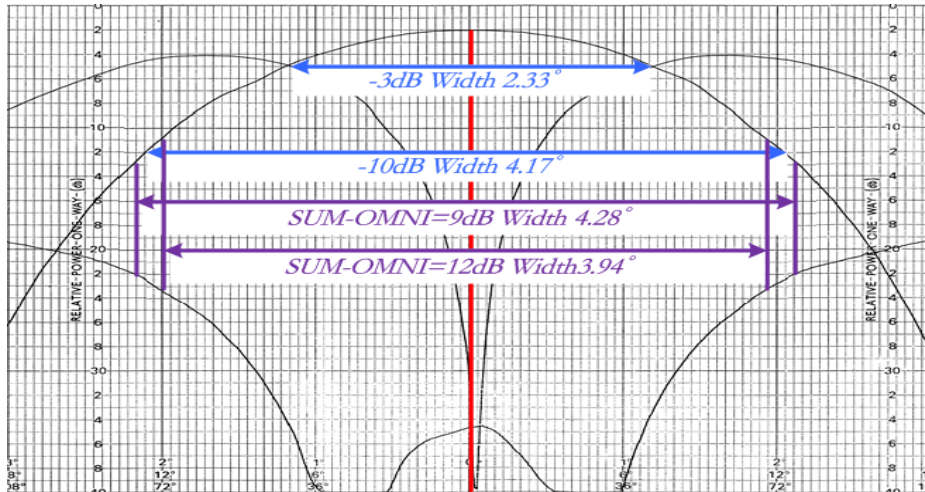
Antenna Period T_a

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.

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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:

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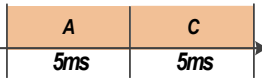
No.	Mode	Description	Pulse Used
1	A	Mode A interrogation	8 μ s between P1 and P3
2	C	Mode C interrogation	21 μ s between P1 and P3
3	A _S	Mode A Only All-Call	8 μ s between P1 and P3, and short P4
4	C _S	Mode C Only All-Call	21 μ s between P1 and P3, and short P4
5	S _L	Mode ACS All-Call	8 μ s, 21 μ s between P1 and P3, and Long P4
6	S _{PO}	Mode S Only All-Call P for PR, O for LO	2 μ s between P1 and P2, and P6 UF11 inside P6
7	R	Mode S Roll-Call	2 μ s 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.

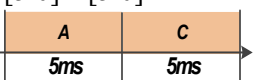
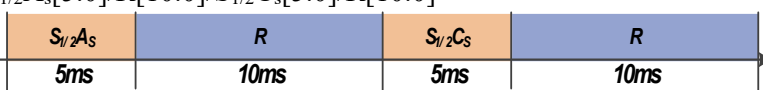
6.4 An example is show as follows:

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***

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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 $\frac{3.8}{360} * 3800 \approx 40.1ms$

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5	Tac All-Call Period	ms	3.0	Equivalent Coverage Range $\frac{3 * 10^8 * 3.0 * 10^{-3}}{1852 * 2} \approx 243\text{NM}$
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

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- 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 μ s	20.75 μ s
Mode 2	5.8 μ s	20.75 μ s
Mode 3/A	8.8 μ s	20.75 μ s

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Mode C	21.8 μ s	20.75 μ s
Mode C (Whisper/Shout)	23.8 μ s	20.75 μ s
Mode A only All Call	10.8 μ s	20.75 μ s
Mode C only All-Call	23.8 μ s	20.75 μ s
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 analyses 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 equipment of aircraft operating in the geographical area surrounding the measurement location.

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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 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.

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 SURVEILLANCE STRATEGY FOR THE APAC REGION

Considering that:

1. States are implementing CNS/ATM systems to gain safety, efficiency and environmental benefits, and have endorsed the move toward satellite and data link technologies;
2. The future air traffic environment will require increased use of aircraft-derived surveillance information for the implementation of a seamless automated air traffic flow management system;
3. The 11th Air Navigation Conference endorsed the use of ADS-B as an enabler of the global air traffic management concept and encouraged States to support cost-effective early implementation of ADS-B applications;
4. The 12th Air Navigation Conference endorsed the ICAO Aviation System Block Upgrades (ASBU) Framework with Modules specifying effective use of ADS-B/MLAT and associated communication technologies in bridging surveillance gaps and its role in supporting future trajectory-based ATM operating concepts. Cooperation between States is the key to achieve harmonized ATM system operations;
5. The 13th Air Navigation Conference endorsed the multilayer structure for the GANP, the ASBU and initial version of basic building block (BBB) frameworks and its change management process, which are available in an interactive format as part of the web-based GANP Portal. This allows ICAO to incorporate a flexible framework for new/emerging surveillance-related concepts such as space based ADS-B into future editions of the GANP;
6. APANPIRG has decided to use the 1090MHz Extended Squitter data link for ADS-B air-ground and air-air applications in the Asia/Pacific Region;
7. Use of surveillance systems that do not require GNSS will continue to meet many critical surveillance needs for the foreseeable future;
8. SARPs, PANS and guidance material for the use of ADS-B have been developed;
9. Availability of new technologies, such as space based ADS-B which is now operationally used by some States;
10. Mode S and ADS-B avionics (including DAPs) and processing systems are available;

11. ADS-B IN applications and equipment are now available in commercial airliners and ICAO ASBUs include ADS-B IN applications;
12. There are continuing significant pressures on the radio spectrum for purposes outside aviation, particularly in the primary radar spectrum; and
13. ADS-B security issues are addressed by the ADS-B regional guidance material and security issues of Mode S surveillance may need to be further considered in the future.

THE SURVEILLANCE STRATEGY FOR THE ASIA/PACIFIC REGION IS TO:

1. Minimize the reliance upon pilot position reporting, particularly voice position reporting, for surveillance of aircraft;
2. Maximize the use of ADS-B on major air routes and in terminal areas, giving consideration to the mandatory carriage of ADS-B Out as specified in *Note 1* and use of ADS-B for ATC separation service;
3. Reduce the dependence on Primary Radar for area surveillance, consider the ongoing need for primary radars in terminal areas with a view to reducing primary surveillance coverage or use of phased array radar or other technologies with coverage focusing on areas of concern, and the potential use of alternate technologies or procedures (e.g. transponder veil regulations);
4. Encourage deployment of Mode S systems instead of Mode A/C only radars when replacement is required;
5. Provide maximum contiguous ATS surveillance coverage of air routes using 1090MHz Extended Squitter (1090ES) ADS-B, Wide Area Multilateration and Mode S SSR to meet operational and safety requirements;
6. Make full use of aircraft Mode S capabilities, where suitable surveillance systems and ATM automation systems are available, to reduce reliance on 4-digit octal codes. Mode S capabilities such as DAPs should also be considered for use to support ATM services where appropriate;
7. Make use of alternative technologies where technical constraint or comparative cost benefit analysis does not support the use of ADS-B, SSR or Multilateration;
8. Make use of Multilateration and/or ADS-B for surface, terminal and area surveillance where appropriate, feasible and cost effective;
9. Monitor ADS-B OUT developments such as Version 3 (DO-260C) MOPS development, and Version 2 (DO260B) equipage in the APAC region. At an appropriate time (circa 2020) APAC States should review progress and consider development of transition plans where cost/benefit studies indicate positive advantages for the region;
10. Monitor ADS-B IN development and cost benefits to ensure that APAC States are able to take advantage of ADS-B IN benefits when appropriate, through procedures, rules and ATC automation capabilities;

11. To the extent possible, implement ADS-B in the non-radar environment as a priority. In the radar or other surveillance environment, use ADS-B to supplement or replace existing surveillance coverage, subject to local factors and risk assessment;
12. Make use of surveillance capability to support the GADSS as appropriate;
13. Implementation of surveillance capability should also include consideration of contingency surveillance requirements ^{Note 2} and multilayer surveillance provision should be implemented to enhance the availability of surveillance services;
14. Monitor development of surveillance systems to support integration of UAS including new technology capable to detect non cooperative targets such as UAS.
15. Encourage sharing of surveillance data, utilizing provisions in the Region such as CRV, to improve safety and efficiency in air traffic management with a justifiable cost; and
16. Monitor potential congestion on 1090 MHz by means of routine measurements of channel occupancy, at both terrestrial and airborne levels, and monitor the availability of 24-bit aircraft address

Note 1:

- a) *Version 0 ES as specified in Annex 10, Volume IV, Chapter 3, Paragraph 3.1.2.8.6 (up to and including Amendment 82 to Annex 10) and Chapter 2 of Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871) (Equivalent to DO260) to be used till at least 2020.*
- b) *Version 1 ES as specified in Chapter 3 of Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871) (Equivalent to DO260A);*
- c) *Version 2 ES as specified in Chapter 4 of Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871) (Equivalent to DO260B).*
- d) *States/Administrations in APAC region are strongly encouraged to mandate aircraft with a maximum take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, to be equipped with ADS-B OUT avionics compliant with Version 2 ES (DO-260B) or later version with date of manufacture on or after 1 January 2020.*

Note 2:

Contingency surveillance requirements are requirements to handle contingency situations in surveillance thus retain capacity to continue providing/using air navigation services. Such situations include but are not limited to the followings:

- *failure of surveillance system or infrastructure such as ground stations or GNSS failure;*
- *avionics failure or equipped aircraft transmitting bad data in flight with good data integrity indicators.*



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

**ADS-B IMPLEMENTATION AND
OPERATIONS GUIDANCE DOCUMENT**

Edition 15.0 - September 2022

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Appendix 1 – An Example of Commissioning Checklist

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Appendix 3 – A Template for ADS-B Mandate/Regulations for Aircraft Avionics

Appendix 4 – An Example of Advice to Operators Concerning Inconsistency between ADS-B Flight Planning and Surveillance Capability

Appendix 5 – Checklist of Common Items or Parameters for the Monitoring of ADS-B System

Appendix 6 – Baseline ADS-B Service Performance Parameters

Appendix 7 – Guidance Material on Generation, Processing and Sharing of ASTERIX Category 21 ADS-B Messages

Appendix 8 – ICAO Guidance Material on 1 090 Mhz Spectrum Issues and Proper Management of 24-Bit Aircraft Addresses Associated with Unmanned Aircraft

1. INTRODUCTION

The Eleventh ICAO Air Navigation Conference held in 2003 recommended that States recognize ADS-B as an enabler of the global ATM concept bringing substantial safety and capacity benefits; support the cost-effective early implementation of it; and ensuring it is harmonized, compatible and interoperable with operational procedures, data linking and ATM applications.

The Twelve ICAO Air Navigation Conference held in 2012 endorsed the Aviation System Block Upgrades (ASBU) to provide a framework for global harmonization and interoperability of seamless ATM systems. Among the Block Upgrades, the Block 0 module “Initial Capability for Ground Surveillance” recommends States to implement ADS-B which provides an economical alternative to acquire surveillance capabilities especially for areas where it is technically infeasible or commercially unviable to install radars.

This ADS-B Implementation and Operations Guidance Document (AIGD) provides guidance material for the planning, implementation and operational application of ADS-B technology in the Asia and Pacific Regions.

The procedures and requirements for ADS-B operations are detailed in the relevant States’ AIP. The AIGD is intended to provide key information on ADS-B performance, integration, principles, procedures and collaboration mechanisms.

The content is based upon the work to date of the APANPIRG ADS-B Study and Implementation Task Force (SITF), the Surveillance Implementation Coordination Group (SURICG) and various ANC Panels developing provisions for the operational use of ADS-B. Amendment to the guidance material will be required as new/revised SARPs and PANS are published.

1.1 ARRANGEMENT OF THE AIGD

The AIGD consists of the following Parts:

Section 1	Introduction
Section 2	Acronyms and Glossary of Terms
Section 3	Reference Documents
Section 4	ADS-B Data
Section 5	ADS-B Implementation
Section 6	Template of Harmonization Framework for ADS-B Implementation
Section 7	System Integrity and Monitoring
Section 8	Reliability and Availability Considerations
Section 9	ADS-B Regulations and Procedures
Section 10	Security Issues Associated with ADS-B

1.2 DOCUMENT HISTORY AND MANAGEMENT

This document is managed by the APANPIRG. It was introduced as draft to the first Working Group meeting of the ADS-B SITF in Singapore in October 2004, at which it was agreed to develop the draft to an approved working document that provides implementation guidance for States. The first edition was presented to APANPIRG for adoption in August 2005. It is intended to supplement SARPs, PANS and relevant provisions contained in ICAO documentation and it will be regularly updated to reflect evolving provisions.

1.3 COPIES

Paper copies of this AIGD are not distributed. Controlled and endorsed copies can be found at the following web site: <http://www.icao.int/APAC/Pages/edocs.aspx>

Copy may be freely downloaded from the web site, or by emailing APANPIRG through the ICAO Asia and Pacific Regional Office who will send a copy by return email.

1.4 CHANGES TO THE AIGD

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (see Section 1.6 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 agreed by a meeting of the Surveillance Implementation Coordination Group then a new version of the AIGD 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 AIGD will be the responsibility of APANPIRG.

1.5 EDITING CONVENTIONS (Intentionally blank)

1.7 AMENDMENT RECORD

Amendment Number	Date	Amended by	Comments
0.1	24 December 2004	W. Blythe H. Anderson	Modified draft following contributions from ADS-B SITF Working Group members. Incorporated to TF/3 Working Paper #3.
0.2 (1.0)	24 March 2005	H. Anderson	Final draft prepared at ADS-B SITF WG/3
0.3 (1.1)	03 June 2005	Nick King	Amendments following SASP WG/WHL meeting of May 2005
0.4	15 July 2005	CNS/MET SG/9	Editorial changes made
1.0	26 August 2005	APANPIRG/16	Adopted as the first Edition
2.0	25 August 2006	Proposed by ADS-B SITF/5 and adopted by APANPIRG/17	Adopted as the second Edition
3.0	7 September 2007	Proposed by ADS-B SITF/6 and adopted by APANPIRG/18	Adopted as the second amendment (3 rd edition)
4.0	5 September 2011	Proposed by ADS-B SITF/10 and adopted by APANPIRG/22	Adopted amendment on consequential change to the Flight Plan and additional material on the reliability and availability for ADS-B ground system
5.0	14 September 2012	Proposed by ADS-B SITF/11 and adopted by APANPIRG/23	Included sample template on harmonization framework
6.0	June 2013	Proposed by ADS-B SITF/12 and adopted by APANPIRG/24	Revamped to include the latest ADS-B developments and references to guidance materials on ADS-B implementation
7.0	September 2014	Proposed by ADS-B SITF/13 and adopted by APANPIRG/25	(i) Included guidance materials on monitoring and analysis of ADS-B equipped aircraft (ii) Included guidance materials on synergy between GNSS and ADS-B (iii) Revised ATC Phraseology (iv) Included clarification on Flight Planning
8.0	September 2015	Proposed by ADS-B SITF/14 and adopted by APANPIRG/26	(i) Updated the guidance materials on monitoring and analysis of ADS-B equipped aircraft (ii) Updated the categories of reported ADS-B avionics problems (iii) Updated the guidance materials on ADS-B flight plan (iv) Updated the guidance materials on disabling ADS-B transmissions (v) Remove reference to operational

			approval for use of ADS-B Out by ATC
9.0	September 2016	Proposed by ADS-B SITF/15 and adopted by APANPIRG/27	(i) Included a list of additional functional requirements for ADS-B integration (ii) Addition of a checklist of common items or parameters for monitoring of ADS-B System (iii) Amendment to emphasize the issue on potential incorrect processing of DO-260B downlinks by ADS-B ground stations during upgrade (iv) Updated the list of known ADS-B avionics problems (v) Included a general recommendation of technical solution on acquisition of Mode 3/A code information via Mode S downlink for DO-260 aircraft in ADS-B implementation with Mode A/C SSR environment
10.0	June 2017	Proposed by SURICG/2	(i) Updated “B787 position error with good NUC” in the list of known ADS-B avionics problems. (ii) Included new problem type “Incorrect Ground Bit Setting in ADS-B Avionics Downlink Data” and “A350 ADS-B on-ground performance” in the list of known ADS-B avionics problems. (iii) Amendment to the template for ADS-B Mandate / Regulations for Aircraft Avionics. (iv) Included a general recommendation to use ADS-B in overcoming the limitations of Mode A/C radar technology. (v) Included a general recommendation on carrying out ICAO Aircraft Address Monitoring (vi) Aligned to replace NACp for NAC throughout the document (vii) Aligned to use ICAO Aircraft Address throughout the document
11.0	April 2018	Proposed by SURICG/3	(i) Editorial Updates – including /replacing ADS-B SITF with SURICG (Sections 1, 1.4, 2.1, 7.5.1, 7.5.5, 7.5.6, 7.6, 7.8.2) (ii) Correction of HPL Definition (Section 2.2) (iii) Update of reference documents as in Attachment 2 of WP/02 (iv) Include reference to APRD (Section

			7.5.1) (v) Update of sample regulations (Section 9.2) (vi) Update in Position Reporting Performance (Section 9.3.2) (vii) Update in GNSS Integrity Prediction Service (Section 9.3.3) (viii) Update name of RASMAG in Sharing of ADS-B Data (Section 9.3.4) (ix) Clarification of reporting rate requirements (Section 9.4.1) (x) Use of Ident during ADS-B emergencies.(Section 9.12) (xi) Appendix 1 missing from Version 10 – reinstate. (xii) Appendix 2 – update for available APRD. (xiii) Update to B787 service bulletin status. (Attachment A in Appendix 2) (xiv) replace "Date UTC" to "Start Time/Date UTC", replace "Time UTC" to "End Time/Date UTC" and related contents in the Report Form (Section 7.8.1) (xv) replace description of "Date UTC" as "UTC Time/Date when the event occurred", replace description of "Time UTC" as "UTC Time/Date when the event ended" as sometimes the problem will lasts across mid-night. (Section 7.8.2) (xvi) In Remote Control & Monitoring (RCMS) part, suggest to replace "ASTERIX Output Load" to "ASTERIX Output Load and Link Status" (Appendix 5) (xvii) Update on DO260A EMG issue (Section 9.12) (xviii) Update the link to the Guidance Material on generation, processing and sharing of ASTERIX (Section 4) (xix) Reference to Space based ADS-B and ATC automation as in WP12 is added under 5.1.4.4.6 (xx) Updated Section 4Managing the Problem in Appendix 2 to incorporate the General mechanism and procedure for blacklisting aircraft (xxi) Updated the Attachment A to Appendix 2 – List of known ADS-B avionics problems (xxii) Added Appendix 6 – Baseline ADS-B Service Performance Parameters

			(xxiii) Added Appendix 7 – Guidance Material on Generation, Processing and Sharing of ASTERIX Category 21 ADS-B Messages
12.0	April 2019	Proposed by SURICG/4	(i) Added procedures on handling GPS time and week counters rollover (Section 9.13) (ii) Added two new problem types to Attachment A of Appendix 2 “List of known ADS-B avionics problems”, including: ○ Rockwell TSS-4100 Geometric Altitude Reporting as Pressure Altitude ○ Improper NACv reporting (iii) Updated the status of known ADS-B avionics problems in Attachment A of Appendix 2 “List of known ADS-B avionics problems”, including: ○ B787 position error with good NIC ○ Rockwell TSS-4100 track extrapolation issue ○ Embraer 170 track jumping issue ○ Airbus Single Aisle production wiring issue ○ Boeing 777-300ER production wiring issue
13.0	September 2020	Proposed by SURICG/5	(i) Updated the status of known ADS-B avionics problems in Attachment A of Appendix 2 “List of known ADS-B avionics problems”, including B787 NACv = 0 Issue (ii) Updated Section 5.1.4.5.1 on ICAO Aircraft Address Monitoring (iii) Added the following new sections: ○ Use of ADS-B for Airport Surface Movement (Section 9.3.6) ○ 1090 Mhz Spectrum and 24-bit Aircraft Address Issue with Unmanned Aircraft Systems (UAS) (Section 9.3.7) ○ Measures for Enhancing the Security of ADS-B (Section 10.3) ○ Time Difference of Arrival

			(TDOA) Based Position Verification Method (Section 10.3.1)
14.0	August 2021	Proposed by SURICG/6	(i) Added the following new issue to the “List of known ADS-B avionics problems” in Attachment A of Appendix 2 ○ Honeywell Primus II RCZ Issue
15.0	May 2022	Proposed by SURICG/7	(i) Added Section 9.3.8 on Methodologies to Avoid or Reduce 1090 MHz Congestion (ii) Added Section 10.3.2 on Appropriate Implementation of a Decoding Method of CPR

2. ACRONYM LIST & GLOSSARY OF TERMS

2.1 ACRONYM LIST

ACID	Aircraft Identification
ADS-C	Automatic Dependent Surveillance - Contract
ADS-B	Automatic Dependent Surveillance - Broadcast
AIGD	ADS-B Implementation and Operations Guidance Document
AIP	Aeronautical Information Publication
AIT	ADS-B Implementation Team
AMSL	Above Mean Sea Level
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APRD	ADS-B Avionics Problem Reporting Database
ARINC	Aeronautical Radio Incorporated
ATC	Air Traffic Control (or Air Traffic Controller)
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSP	ATS Provider
ATSU	ATS unit
CNS	Communications, Navigation, Surveillance
CRC	Cyclic Redundancy Check
CDTI	Cockpit Display Traffic Information
DAIW	Danger Area Infringement Warning
FIR	Flight Information Region
FLTID	Flight Identification
FMS	Flight Management System
FOM	Figure of Merit used in ASTERIX messaging
GPS	Global Positioning System (USA)
HPL	Horizontal Protection Level
ICAO	International Civil Aviation Organization
MSAW	Minimum Safe Altitude Warning
MTBF	Mean Time Between Failures
MTCA	Medium Term Conflict Alert
MTTR	Mean Time To Restore
NACp	Navigation Accuracy Category
NIC	Navigation Integrity Category
PRS	Problem Reporting System
RAI	Restricted Area Intrusion
RAM	Route Adherence Monitoring
RAIM	Receiver Autonomous Integrity Monitoring
RFC	Request for Change
RNP	Required Navigation Performance
SIL	Source Integrity Level
SITF	Study and Implementation Task Force
STCA	Short Term Conflict Alert
SURICG	Surveillance Implementation Coordination Group

2.2 GLOSSARY OF TERMS

ADS-B In	An ADS-B system feature that enables the display of real time ADS-B tracks on a situation display in the aircraft cockpit.
ADS-B Out	An ADS-B system feature that enables the frequent broadcast of accurate aircraft position and vector data together with other information.
Asterix 21	Eurocontrol standard format for data message exchange
FOM (Figure of Merit)	A numeric value that is used to determine the accuracy and integrity of associated position data.
HPL (Horizontal Position Limit)	The containment radius within which the true position of the aircraft will be found for 99.999% of the time, or the probability indicated by the reported SIL value (DO-260A/B).
NACp (Navigational Accuracy Category)	Subfield used to announce the 95% accuracy limits for the horizontal position data being broadcast.
NIC (Navigational Integrity Category)	Subfield used to specify the containment radius integrity associated with horizontal position data.
NUCp (Navigation Uncertainty Category)	A numeric value that announces the integrity of the associated horizontal position data being broadcast.
SIL (Source Integrity Level)	Subfield used to specify the probability of the true position lying outside the containment radius defined by NIC without being alerted.

3. REFERENCE DOCUMENTS

Id	Name of the document	Reference	Date	Origin	Domain
1	Annex 2: Rules of the Air	Tenth Edition Including Amendment 43 dated 10/11/16	July 2005	ICAO	
2	Annex 4: Aeronautical Chart	Eleventh Edition including Amendment 59 dated 10/11/16	July 2009	ICAO	
3	Annex 10: Aeronautical Telecommunications, Vol. IV – Surveillance Radar and Collision Avoidance Systems	Fifth Edition	July 2014	ICAO	
4	Annex 11: Air Traffic Services	Fourteenth Edition	July 2016	ICAO	
5	Annex 15: Aeronautical Information Services	Fifteenth Edition	July 2016	ICAO	
6	PAN-ATM (Doc 4444/ATM501)	Sixteenth Edition	November 2016	ICAO	
7	Air Traffic Services Planning Manual (Doc 9426/AN924)	First Edition including Amendment 4 30/12/92	1984	ICAO	
8	Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689/AN953)	First Edition including Amendment 1 dated 30/8/02	1998	ICAO	
9	Doc 9859 Safety Management Manual (SMM)	Third Edition	2013	ICAO	
10	Technical Provisions for Mode S Services and Extended Squitter (Doc 9871/AN460)	Second Edition including Amendment 1 dated 09/01/17	2012	ICAO	
11	Aeronautical Surveillance Manual (Doc 9924)	Second Edition	2017	ICAO	
12	ICAO Circular 326 AN/188 “Assessment of ADS-B and Multilateration Surveillance to Support Air Traffic Services and Guidelines for Implementation”.	First Edition	2012	ICAO	
13	Regional Supplementary Procedures (Doc 7030)	Fifth Edition including Amendment 9 dated 25/04/14	2008	ICAO	
14	Minimum Operational Performance Standards (MOPS) for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) – including Change 1	RTCA DO-260 September 13, 2000 Change 1 to RTCA DO-260	2000 2006	RTCA	

		June 27, 2006			
15	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 April 10, 2003	2003	RTCA	
	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B) – Change 1	RTCA DO-260A Change 1 June 27, 2006	2006		
	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B) – Change 2	RTCA DO-260A Change 2 December 13, 2006	2006		
16	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services (TIS-B)	RTCA DO-260B December 2, 2009	2009	RTCA	
	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B) – Corrigendum 1	RTCA DO-260B December 13, 2011	2011		

4. ADS-B DATA

APANPIRG has decided to use 1090MHz Extended Squitter data link for ADS-B data exchange in the Asia and Pacific Regions. In the longer term an additional link type may be required.

To ensure interoperability of ADS-B ground stations in the Asia Pacific (ASIA/PAC) Regions, during the 16th APANPIRG Meeting held in August 2005, the ASTERIX Category 21 version 0.23 (V0.23) which had incorporated DO260 standard was adopted as the baselined ADS-B data format for deployment of ADS-B ground stations and sharing of ADS-B data in the ASIA/PAC Regions. At this time, DO260A and DO260B standards were not defined.

This baselined version provides adequate information so that useful ATC operational services, including aircraft separation, can be provided. V0.23 can be used with DO260, DO260A and DO260B ADS-B avionics/ground stations to provide basic ATC operational services. However, V0.23 cannot fully support the more advanced capabilities offered by DO260A and DO260B.

As the avionics standards changed through the different versions of DO260, the ADS-B ground station processing also needed to change, so that downlinks received from aircraft would be correctly interpreted in construction of the ASTERIX Category 21 messages. It is important that States with “older generation” ADS-B ground stations designed to support DO260 or DO260A, take action to upgrade to support the latest ADS-B avionics standard as well as the older standards. DO260B avionics will become more common in the Asia Pacific region as the FAA and European ADS-B mandates for 2020 require this version.

States intending to implement ADS-B surveillance and share ADS-B data with others might consider to adopt a more updated version of ASTERIX in order to make use of the advanced capabilities offered by DO260A and DO260B compliant avionics.

A guidance material on generation, processing and sharing of ASTERIX Cat. 21 ADS-B messages is provided at **Appendix 7** for reference by States.

In this guidance material, the ADS-B data contained inside ASTERIX Cat 21 are classified as Group 1 (mandatory), Group 2 (Desirable) and Group 3 (Optional). It is required to transmit all data that are operationally desirable (Group 2), when such data are received from the aircraft, in addition to the data that are mandatory (Group 1) in ASTERIX messages. Whether Group 3 optional data will need to be transmitted or not should be configurable on item-by-item basis within the ADS-B ground station depending on specific operational needs.

It is considered necessary that all data that are mandatory in ASTERIX messages (i.e. Group 1 data items) and operationally desirable (i.e. Group 2 data items) when such data are received from aircraft, should be included in data sharing. In the event that the data have to be filtered, the list of optional data items (i.e. Group 3 data items) needs to be shared will be subject to mutual agreement between the two data sharing parties concerned.

5. ADS-B IMPLEMENTATION

5.1 INTRODUCTION

5.1.1 Planning

There are a range of activities needed to progress ADS-B implementation from initial concept level to operational use. This section addresses the issues of collaborative decision making, system compatibility and integration, while the second section of this chapter provides a checklist to assist States with the management of ADS-B implementation activities.

5.1.2 Implementation team to ensure international coordination

5.1.2.1 Any decision to implement ADS-B by a State should include consultation with the wider ATM community. Moreover, where ADS-B procedures or requirements will affect traffic transiting between states, the implementation should also be coordinated between States and Regions, in order to achieve maximum benefits for airspace users and service providers.

5.1.2.2 An effective means of coordinating the various demands of the affected organizations is to establish an implementation team. Team composition may vary by State or Region, but the core group responsible for ADS-B implementation planning should include members with multidiscipline operational expertise from affected aviation disciplines, with access to other specialists where required.

5.1.2.3 Ideally, such a team should comprise representatives from the ATS providers, regulators and airspace users, as well as other stakeholders likely to be influenced by the introduction of ADS-B, such as manufacturers and military authorities. All identified stakeholders should participate as early as possible in this process so that their requirements can be identified prior to the making of schedules or contracts.

5.1.2.4 The role of the implementation team is to consult widely with stakeholders, identify operational needs, resolve conflicting demands and make recommendations to the various stakeholders managing the implementation. To this end, the implementation team should have appropriate access to the decision-makers.

5.1.3 System compatibility

5.1.3.1 ADS-B has potential use in almost all environments and operations and is likely to become a mainstay of the future ATM system. In addition to traditional radar-like services, it is likely that ADS-B will also be used for niche application where radar surveillance is not available or possible. The isolated use of ADS-B has the potential to foster a variety of standards and practices that, once expanded to a wider environment, may prove to be incompatible with neighbouring areas.

5.1.3.2 Given the international nature of aviation, special efforts should be taken to ensure harmonization through compliance with ICAO Standards and Recommended Practices (SARPs). The choice of systems to support ADS-B should consider not only the required performance of individual components, but also their compatibility with other CNS systems and prevailing avionics standards.

5.1.3.3 The future concept of ATM encompasses the advantages of interoperable and seamless transition across flight information region (FIR) boundaries and, where necessary, ADS-

B implementation teams should conduct simulations, trials and cost/benefit analysis to support these objectives.

5.1.4 Integration

5.1.4.1 ADS-B implementation plans should include the development of both business and safety cases. The adoption of any new CNS system has major implications for service providers, regulators and airspace users and special planning should be considered for the integration of ADS-B into the existing and foreseen CNS/ATM system. The following briefly discusses each element.

5.1.4.2 Communication system

5.1.4.2.1 The communication system is an essential element within CNS. An air traffic controller can now monitor an aircraft position in real time using ADS-B where previously only voice position reports were available. However, a communication system that will support the new services that result from the improved surveillance may be necessary. Consequently, there is an impact of the ongoing ADS-B related work on the communication infrastructure developments.

5.1.4.3 Navigation system infrastructure

5.1.4.3.1 ADS-B is dependent upon the data obtained from a navigation system (typically GNSS), in order to enable its functions and performance. Therefore, the navigation infrastructure should fulfill the corresponding requirements of the ADS-B application, in terms of:

- a) Data items; and
- b) Performance (e.g. accuracy, integrity, availability etc.).

5.1.4.3.2 This has an obvious impact on the navigation system development, which evolves in parallel with the development of the surveillance system.

5.1.4.4 Other surveillance infrastructure

5.1.4.4.1 ADS-B may be used to supplement existing surveillance systems or as the principal source of surveillance data. Ideally, surveillance systems will incorporate data from ADS-B and other sources to provide a coherent picture that improves both the amount and utility of surveillance data to the user. The choice of the optimal mix of data sources will be defined on the basis of operational demands, available technology, safety and cost-benefit considerations.

5.1.4.4.2 ADS-B is one of the cost-effective means in complementing and overcoming limitations of Mode A/C radars, including false targets, aircraft positions temporarily not displayed and split tracks, which could cause aircraft display issues on radar screens for ATC irrespective of brands of Air Traffic Management System being used. Within busy airspace, aircraft could be managed at close lateral distance while vertically separated. In such situation, Mode A/C radars sometimes provide garbled detection, in the form of false targets due to overlapping replies from two or more aircraft. In the case of ADS-B, ADS-B data are broadcast in an omni-directional,

random and periodic intervals without suffering from the same issue. In addition, automatic data validation is usually done at ADS-B receivers to ensure integrity of ADS-B information received from the aircraft.

- 5.1.4.4.3 A guidance material on issues to be considered in ATC multi-sensor fusion processing including integration of ADS-B data is provided on the ICAO website <http://www.icao.int/APAC/Pages/edocs.aspx> for reference by States.
- 5.1.4.4.4 Acquisition of Mode 3/A code for DO-260 aircraft through Mode S downlink

There is a potential problem for some of the air traffic management systems (ATMS) for fusion of ADS-B targets with Mode A/C SSR targets, because a common identifier to the aircraft, Mode 3/A code, is not available through ADS-B. Then ATMS can only rely on proximity analysis of aircraft position and Mode C altitude to determine whether detections from two distinct types of surveillance sources belong to the same aircraft. This matching technique might introduce ambiguity in associating ADS-B with Mode A/C SSR targets for fused display.

States may consider enhancing their ADS-B ground stations to listen to Downlink Format 5 and 21 (DF 5 and 21) of Mode S interrogation replies which carry the Mode 3/A code of the same aircraft. As a result, ADS-B target reports of the same DO-260 aircraft can be filled with Mode 3/A code acquired from Mode S downlink to facilitate matching with Mode A/C SSR targets before transmitting to the ATMS.

The transmission of DF 5 and DF 21 messages from a Mode S aircraft requires to be triggered by ground-based Mode S interrogators, either through active or passive interrogation. For active interrogation, Mode S interrogators can be installed alongside with ADS-B ground stations for actively triggering DF 5 and DF 21 messages transmission from the aircraft. The interrogators shall follow ICAO standard to perform periodic all-call and roll-call to the aircraft in range. For passive interrogation, the ADS-B ground stations will only passively listen to the DF messages from the aircraft for acquiring the Mode 3/A code. It is required to ensure that Mode S interrogations are performed by external systems, such as A-SMGCS, MLAT system or Mode S radar under their coverage.

The above provides an interim solution during transition from Mode A/C SSR to Mode S SSR. After upgrading to Mode S SSR, ATMS can have an alternative means to make use of Flight ID or ICAO Aircraft Address to perform association between ADS-B and Mode S radar targets without ambiguity.

- 5.1.4.4.5 A guidance material on processing and displaying of ADS-B data at air traffic controller positions is provided on the ICAO website ["http://www.icao.int/APAC/Pages/edocs.aspx"](http://www.icao.int/APAC/Pages/edocs.aspx) for reference by States.
- 5.1.4.4.6 Most of the ATC automation systems that support terrestrial ADS-B will also support space-based ADS-B without modifications. For more guidance, reference can be made to WP/12 on "ATC Automation Requirement and Space-based ADS-B" delivered during 3rd meeting of the SURICG.

5.1.4.5 Additional Functional Requirements for ADS-B Integration

5.1.4.5.1 The following list of functions could be considered by each individual States to see whether they are suitable for their own operational needs or applicable to local environment from ADS-B integration point of view:

- The priority of ADS-B sensor position data vs radar data could be adaptable;
- For ADS-B aircraft, receipt of the Mode S conspicuity code could trigger use of the Flight ID / ICAO Aircraft Address for flight plan correlation;
- If, due to sensor or aircraft capability limitation, no SSR code is received for an aircraft, the system could use Flight ID/ ICAO Aircraft Address for track correlation;
- For correlation based on Flight ID, the received ID could exactly match the ACID of the flight plan;
- For correlation based on ICAO Aircraft Address, the received address could match the address entered in the flight plan item 18 CODE/ keyword;
- The system could generate an alert for a correlated flight for which the Flight ID from the track does not match the flight plan ACID and/or the ICAO Aircraft Address from the track does not match the code given in the flight plan Item 18 CODE/ keyword;
- The system could allow the setting of ADS-B above or below the radar sources within the Surveillance Data Processor Tile Set on a per-tile basis;
- Priority could only apply to data received at or above the adapted NUCp, NACp, NIC, and/or SIL thresholds;
- The system could be configurable to either discard ADS-B data or display the track with an indication of ADS-B degradation if the received NUCp, NACp, NIC, or SIL is below an adapted threshold;
- If the system is configured to display the degraded track, the degraded position and status could only be displayed if there are no other surveillance sources available;
- The system could allow the adaptation of ADS-B emergency codes to map to special Mnemonics;
- The system could include an adaptable Downlinked Aircraft Parameters (DAP) field that invokes a popup with the following information from Mode-S and ADS-B aircraft:
 - Magnetic Heading
 - True Track Angle

- Indicated Airspeed/Mach Number
 - Groundspeed
 - Track Angle Rate
 - True Airspeed
 - Roll Angle
 - Selected Altitude
 - Vertical Rate
- The system could generate a conformance alert if the Selected Altitude and the Cleared Flight Level do not match.
 - The system could monitor¹ the ICAO Aircraft Address of individual aircraft and generate alert for the following cases:
 - ICAO Aircraft Address does not match with that specified in flight plan ICAO Aircraft Address is all 0 or F (expressed in hexadecimal)
 - ICAO Aircraft Address is not defined in ICAO's allocation
 - Duplicate ICAO Aircraft Address detected within single sensor in the same time-frame
 - Duplicate ICAO Aircraft Address detected within multi-sensors in the same time-frame ICAO Aircraft Address changes during the flight
 - Aircrafts whose state identification number is not match with the state information registered in its flight plan
 - Aircrafts whose state identification number is not defined in SARPs (Annex 10)
 - Mode-S transponder of which P4 pulse was not detected
 - Mode-A/C transponder replied to Mode-S all call

5.1.5 Coverage Predictions

- 5.1.5.1 Reliable and robust analysis and planning of ADS-B coverage to support seamless ATM initiative requires accurate and reliable coverage modelling. States should ensure that surveillance engineering/technical teams are provided with modelling tools to provide accurate and reliable coverage predictions for ATM planning and analysis.

¹ Monitoring could be done by ATM system or other systems of the States/Administration

5.2 IMPLEMENTATION CHECKLIST

5.2.1 Introduction

The purpose of this implementation checklist is to document the range of activities that needs to be completed to bring an ADS-B application from an initial concept to operational use. This checklist may form the basis of the terms of reference for an ADS-B implementation team, although some activities may be specific to individual stakeholders. An example of the checklist used by AirServices Australia is given at Appendix 1.

5.2.2 Activity Sequence

The activities are listed in an 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.

5.2.3 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) access; and
- 7) other metrics (e.g. predictability, flexibility, usefulness);

c) identify constraints:

- 1) pair-wise equipage;
- 2) compatibility with non-equipped aircraft;
- 3) need for exclusive airspace;
- 4) required ground infrastructure;
- 5) RF spectrum;
- 6) integration with existing technology; and
- 7) technology availability;

d) prepare business case:

- 1) cost benefit analysis; and
- 2) demand and justification.

5.2.4 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; and
 - 6) required certification levels;
- d) equipment development, test, and evaluation:
- 1) prototype systems built to existing or draft standards/specifications;
 - 2) developmental bench and flight tests; and
 - 3) acceptance test parameters; and
 - 4) select and procure technology;
- e) develop procedures:
- 1) pilot and controller actions and responsibilities;
 - 2) phraseologies;
 - 3) separation/spacing criteria and requirements;
 - 4) controller's responsibility to maintain a monitoring function, if appropriate;
 - 5) contingency procedures;
 - 6) emergency procedures; and
 - 7) develop AIP and Information documentation
- f) prepare design phase safety case:
- 1) safety rationale;
 - 2) safety budget and allocation; and
 - 3) functional hazard assessment.

5.2.5 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) implementation transition:
 - 1) Promulgate procedures and deliver training
 - 2) continue data collection and analysis;
 - 3) resolve any unforeseen issues; and
 - 4) continue feedback into standards development processes;
 - f) performance monitoring to ensure that the agreed performance is maintained.
- 5.2.5.1 Once the implementation project is complete, ongoing maintenance and upgrading of both ADS-B operations and infrastructure should continue to be monitored, through the appropriate forums.

6. HARMONIZATION FRAMEWORK FOR ADS-B IMPLEMENTATION

6.1 BACKGROUND

- 6.1.1 It is obvious that full benefits of ADS-B will only be achieved by its harmonized implementation and seamless operations. During the 6th meeting of ADS-B SEA/WG in February 2011, Hong Kong, China initiated to strengthen collaboration among concerned States/Administrations for harmonized ADS-B implementation and seamless operations along two ATS routes L642 and M771 with major traffic flow (MTF). An ad-hoc workgroup comprising concerned CAAs/ANSPs from Hong Kong, China, Mainland China, Vietnam and Singapore was subsequently formed to elaborate and agree on a framework regarding implementation timelines, avionics standards, optimal flight levels, and ATC and engineering handling procedures. As a coherent effort, ADS-B implementation along ATS routes L642 and M771 has been harmonized while Hong Kong, China and Singapore have published respective Aeronautical Information Circulars and Airworthiness Notices on ADS-B mandates for these two routes with effect on 12 December 2013.
- 6.1.2 It is considered that the above implementation framework for ATS routes L642/M771 would serve as a useful template for extension to other high density routes to harmonize ADS-B implementation. Paragraph 6.2 shows the detailed framework.

6.2 TEMPLATE OF HARMONIZATION FRAMEWORK FOR ADS-B IMPLEMENTATION

Harmonization Framework for ADS-B Implementation along ATS Routes L642 and M771			
No.	What to harmonize	What was agreed	Issue / what needs to be further discussed
1	Mandate Effective	Singapore (SG), Hong Kong (HK), China (Sanya) : 12 Dec 2013 Vietnam (VN) : to be confirmed	
2	ATC Operating Procedures	No need to harmonize	Refer to SEACG for consideration of the impact of expanding ADS-B surveillance on ATC Operating Procedures including Large Scale Weather procedures.
3	Mandate Publish Date	No need to harmonize	To publish equipment requirements as early as possible.

4	Flight Level	SG, HK, CN : - At or Above FL290 (ADS-B airspace) - Below FL290 (Non-ADS-B airspace) VN to be confirmed	
5	Avionics Standard (CASA/AMC2024)	SG - CASA or AMC2024 or FAA AC No. 20-165 HK - CASA or AMC2024 or FAA AC No. 20-165 VN - CASA or AMC2024 or FAA AC No. 20-165 CN - CASA or AMC2024 or FAA AC No. 20-165	ADS-B Task Force agreed that DO260B will be accepted as well. SG, HK, and CN agreed their ADS-B GS will accept DO260, DO260A and DO260B by 1 July 2014 (Note 1)
6	Flight Planning	Before 15 Nov 2012, as per AIGD On or after 15 Nov 2012, as per new flight plan format	
7	Aircraft Equippage		
7a)	Procedures if Aircraft Not Equipped or Aircraft without a Serviceable ADS-B Transmitting Equipment before Flight	SG, HK, CN : FL280 and Below VN to be confirmed	

7b)	Aircraft Equipped but Transmitting Bad Data (Blacklisted Aircraft)	For known aircraft, treat as non ADS-B aircraft.	Share blacklisted aircraft among concerned States/Administration
8	Contingency Plan		
8a)	Systemic Failure such as Ground System / GPS Failure	Revert back to current procedure.	
8b)	Avionics Failure or Equipped Aircraft Transmitting Bad Data in Flight	Provide other form of separation, subject to bilateral agreement. From radar/ADS-B environment to ADS-B only environment, ATC coordination may be able to provide early notification of ADS-B failure.	Address the procedure for aircraft transiting from radar to ADS-B airspace and from ADS-B to ADS-B airspace.
9	Commonly Agreed Route Spacing	SEACG	Need for commonly agreed minimal in-trail spacing throughout.

Note 1: Also included two ADS-B GS supplied by Indonesia at Matak and Natuna

7. SYSTEM INTEGRITY AND MONITORING

7.1 INTRODUCTION

The Communications, Navigation, Surveillance and Air Traffic Management (CNS/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. ADS-B is a surveillance system that may be integrated with other surveillance technologies or may also operate as an independent source for surveillance monitoring within the CNS/ATM system.

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.

These procedures do not replace the ATS incident reporting procedures and requirements, as specified in PANS-ATM (Doc 4444), Appendix 4; ICAO's Air Traffic Services Planning Manual (Doc 9426), Chapter 3; or applicable State regulations, affecting the reporting responsibilities of parties directly involved in a potential ATS incident.

7.2 PERSONNEL LICENSING AND TRAINING

Prior to operating any element of the ADS-B system, operational and technical personnel shall undertake appropriate training as determined by the States, including compliance with the Convention on International Civil Aviation where applicable.

Notwithstanding the above requirement and for the purposes of undertaking limited trials of the ADS-B system, special arrangements may be agreed between the operator and an Air Traffic Services Unit (ATSU).

7.3 SYSTEM PERFORMANCE CRITERIA FOR AN ATC SEPARATION SERVICE

A number of States have introduced ADS-B for the provision of Air Traffic Services, including for surveillance separation. The ICAO Separation and Airspace Safety Panel (SASP) has completed assessment on the suitability of ADS-B for various applications including provision of aircraft separation based on comparison of technical characteristics between ADS-B and monopulse secondary surveillance radar. It is concluded that that ADS-B surveillance is better or at least no worse than the referenced radar, and can be used to provide separation minima as described in PANS-ATM (Doc 4444) whether ADS-B is used as a sole means of ATC surveillance or used together with radar, subject to certain conditions to be met. The assessment result is detailed in the ICAO Circular 326 AN/188 "Assessment of ADS-B and Multilateration Surveillance to Support Air Traffic Services and Guidelines for Implementation".

Regarding the use of ADS-B in complex airspace (as discussed in ICAO Circular 326), complex airspace may be considered to be airspace with the following characteristics:

- Higher aircraft density
- Higher route crossing point density
- A higher mixture of different aircraft performance levels
- A higher rate of aircraft manoeuvring (as distinct from straight and level flight).

The following recommendations need to be considered:

1. Whether complex or not, States are urged to consider whether the current or required surveillance system performance is better, equivalent or worse than the SASP reference.
2. If the current or required surveillance system used by a State is lower or equivalent in performance than the reference MSSR used in Circular 326 Appendix A, then that State may use the Appendix C performance criteria.
3. If the current or required surveillance system used by a State is higher performance than the reference MSSR used in Circular 326 Appendix A, then the State must ensure that the ADS-B system achieves the more demanding performance.
4. State should undertake, in all cases, a safety assessment that ensures that any additional risks and safety requirements already identified for the airspace where ADSB or MLAT is to be implemented, or any newly identified risks, are effectively controlled and risk is reduced to an acceptable level.

States intending to introduce ADS-B separation minima shall comply with provisions of PANS-ATM, Regional Supplementary Procedures (Doc 7030) and Annex 11 paragraph 3.4.1. States should adopt the guidelines contained in this document unless conformance with PANS-ATM specifications requires change.

7.4 ATC SYSTEM VALIDATION

7.4.1 Safety Assessment Guidelines

To meet system integrity requirements, 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 Manuals are compatible with those of adjacent providers where the system is used across a common boundary.

7.4.2 System safety assessment

The objective of the system safety assessment is to ensure the State that introduction and operation of ADS-B is safe. This can be achieved through application of the provisions of Annex 11 paragraph 2.27 and PANS-ATM Chapter 2. The safety assessment should be conducted for initial implementation as well as any future enhancements and should include:

- a) Identifying failure conditions;
- b) Assigning levels of criticality;
- c) Determining risks/ probabilities for occurrence;
- d) Identifying mitigating measures and fallback arrangements;
- e) Categorising 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 conditions that are not already categorized as acceptable. This should be done to reduce the probability of their occurrence to a level as low as reasonably practicable. This could be accomplished through system automation or manual procedures.

Guidance material on building a safety case for delivery of an ADS-B separation service is provided on the ICAO APAC website “<http://www.icao.int/APAC/Pages/edocs.aspx>” for reference by States.

7.4.3 Integration test

States should conduct trials with suitably equipped aircraft to ensure they meet the operational and technical requirements to provide an ATS. Alternatively, they may be satisfied by test results and analysis conducted by another State or organization deemed competent to provide such service. Where this process is followed, the tests conducted by another State or organization should be comparable (i.e. using similar equipment under similar conditions). Refer also to the *Manual on Airspace Planning Methodology for the Determination of Separation Minima* (Doc9689).

7.4.4 ATS Operation Manuals

States should 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.

7.4.5 ATS System Integrity

With automated ATM systems, data changes, software upgrades, and system failures can affect adjacent units. States shall ensure that:

- a) A conservative approach is taken to manage any changes to the system;
- b) Aircrew, aircraft operating companies and adjacent ATSU(s) are notified of any planned system changes in advance, where that system is used across a common boundary;
- c) ATSUs have verification procedures in place to ensure that following any system changes, displayed data is both correct and accurate;
- d) In cases of system failures or where upgrades (or downgrades) or other changes may impact surrounding ATS units, ATSUs should have a procedure in place for timely notification to adjacent units. Such notification procedures will normally be detailed in Letters of Agreement between adjacent units; and
- e) ADS-B surveillance data is provided with equal to or better level of protection and security than existing surveillance radar data.

7.5 SYSTEM MONITORING

During the initial period of implementation of ADS-B technology, routine collection of data is necessary in order 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. The monitoring program is a two-fold process. Firstly, summarised statistical data should be

produced periodically showing the performance of the system. This is accomplished through ADS-B Periodic Status Reports. Secondly, as problems or abnormalities arise, they should be identified, tracked, analyzed and corrected and information disseminated as required, utilizing the ADS-B Problem Report.

Guidance materials on monitoring and analysis of ADS-B Avionics Performance are given at Appendix 2. Checklist of common items or parameters that could be considered for monitoring is summarized at Appendix 5 for reference.

7.5.1 Problem Reporting System (PRS)

The Problem Reporting System is tasked with the collection, storage and regular dissemination of data based on reports received from SURICG members. The PRS tracks problem reports and publish information from those reports to SURICG members. Problem resolution is the responsibility of the appropriate SURICG members.

The PRS Administrator shall:

- a) prepare consolidated problem report summaries for each SURICG meeting;
- b) collect and consolidate ADS-B Problem Reports; and
- c) maintain a functional website (with controlled access) to manage the problem reporting function.

The PRS is managed through the Asia Pacific ADS-B Avionics Problem Reporting Database (APRD) which is accessible to authorized users via <https://applications.icao.int/ADSB-APRD/login.aspx>.

7.5.2 The monitoring process

When problems or abnormalities are discovered, the initial analysis should be performed by the organization(s) identifying the problem. In addition, a copy of the problem report should be entered in to the PRS which will assign a tracking number. As some problems or abnormalities may involve more than one organization, the originator should be responsible for follow-up action to rectify the problem and forward the information to the PRS. It is essential that all information relating to the problem is documented and recorded and resolved in a timely manner.

The following groups should be involved in the monitoring process and problem tracking to ensure a comprehensive review and analysis of the collected data:

- a) ATS Providers;
- b) Organizations responsible for ATS system maintenance (where different from the ATS provider);
- c) Relevant State regulatory authorities;
- d) Communication Service Providers being used;
- e) Aircraft operators; and

- f) Aircraft and avionics manufacturers.

7.5.3 Distribution of confidential information

It is important that information that may have an operational impact on other parties be distributed by the authorised investigator to all authorised groups that are likely to be affected, as soon as possible. In this way, each party is made aware of problems already encountered by others, and may be able to contribute further information to aid in the solution of these problems. The default position is that all states agree to provide the data which will be de-identified for reporting and record keeping purposes.

7.5.4 ADS-B problem reports

Problem reports may originate from many sources, but most will fall within two categories; reports based on observation of one or more specific events, or reports generated from the routine analysis of data. The user would document the problem, resolve it with the appropriate party and forward a copy of the report to the PRS for tracking and distribution. While one occurrence may appear to be an isolated case, the receipt of numerous similar reports by the PRS could indicate that an area needs more detailed analysis.

To effectively resolve problems and track progress, the problem reports should be sent to the nominated point of contact at the appropriate organization and the PRS. The resolution of the identified problems may require:

- a) Re-training of system operators, or revision of training procedures to ensure compliance with existing procedures;
- b) Change to operating procedures;
- c) Change to system requirements, including performance and interoperability; or
- d) Change to system design.

7.5.5 ADS-B periodic status report

The ATS Providers should complete the ADS-B Periodic Status Report annually and deliver the report to the regional meeting of the SURICG. The Periodic Status Report should give an indication of system performance and identify any trend in system deficiencies, the resultant operational implications, and the proposed resolution, if applicable.

Communications Service Providers, if used, are also expected to submit Periodic Status Reports on the performance of the networks carrying ADS-B data at the annual regional meeting of the SURICG. These reports could also contain the details of planned or current upgrades to the network.

7.5.6 Processing of Reports

Each group in the monitoring process should nominate a single point of contact for receipt of problem reports and coordination with the other parties. This list will be distributed by the PRS Administrator to all parties to the monitoring process.

Each State should establish mechanisms within its ATS Provider and regulatory authority to:

- a) Assess problem reports and refer them to the appropriate technical or operational expertise for investigation and resolution;
- b) Coordinate with aircraft operators;
- c) Develop interim operational procedures to mitigate the effects of problems until such time as the problem is resolved;
- d) Monitor the progress of problem resolution;
- e) Prepare a report on problems encountered and their operational implications and forward these to the PRS;
- f) Prepare the ADS-B periodic status report at pre-determined times and forward these to the Secretary of the annual meeting of the SURICG; and
- g) Coordinate with any Communication Service Providers used.

7.6 APANPIRG

APANPIRG, with the assistance of its contributory bodies, shall oversee the monitoring process to ensure the ADS-B system continues to meet its performance and safety requirements, and that operational procedures are working as intended. The APANPIRG'S objectives are to:

- a) review Periodic Status Reports and any significant Problem Reports;
- b) highlight successful problem resolutions to SURICG members;
- c) monitor the progress of outstanding problem resolutions;
- d) prepare summaries of problems encountered and their operational implications; and
- e) assess system performance based on information in the PRS and Periodic Status Reports.

7.7 LOCAL DATA RECORDING AND ANALYSIS

7.7.1 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.

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.

7.7.2 Local data collection

ATS providers and communications service providers should identify and record ADS-B system component failures that have the potential to negatively impact the safety of controlled flights or compromise service continuity.

7.7.3 Avionics problem identification and correction

ATS providers need to develop systems to:

- a) detect ADS-B avionics anomalies and faults
- b) advise the regulators and where appropriate the aircraft operators on the detected ADS-B avionics anomalies and faults
- c) devise mechanisms and procedures to address identified faults

Regulators need to develop and maintain systems to ensure that appropriate corrective actions are taken to address identified faults.

7.8 ADS-B PROBLEM REPORT

7.8.1 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			

7.8.2 Description of Fields

Field	Meaning
Number	A unique identification number assigned by the PRS Administrator to this problem report. Organizations writing problem reports are encouraged to maintain their own 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 occurred.
End Time/Date UTC	UTC time/date when the event ended.
Registration	Registration number (tail number) of the aircraft involved.
Aircraft ID (ACID)	Coded equivalent of voice call sign as entered in FPL Item 7.
ICAO Aircraft Address	Unique ICAO Aircraft Address expressed in Hexadecimal form (e.g. 7432DB)
Flight ID (FLTID)	The identification transmitted by ADS-B for display on a controller situation display or a CDTI.
Flight Sector/Location	The departure airport and destination airport for the sector being flown by the aircraft involved in the event. These should be the ICAO identifiers of those airports. Or if more descriptive, the location of the aircraft during the event.
Originator	Point of contact at the originating organization for this report (usually the author).
Aircraft Type	The aircraft model involved.
Organization	The name of the organization (airline, ATS provider or communications service provider) that created the report.
ATS Unit	ICAO identifier of the ATC Center or Tower controlling the aircraft at the time of the event.
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 complete description of the problem that is being reported • The route contained in the FMS and flight plan • Any flight deck indications • Any indications provided to the controller when the problem occurred • 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.

8. RELIABILITY & AVAILABILITY CONSIDERATIONS

Reliability and Availability of ADS-B systems should normally be equivalent or better than the reliability and availability of radar systems.

Guidance material on Reliability and Availability standards for ADS-B systems and supporting voice communications systems are included in the document “Baseline ADS-B Service Performance Parameters” at **Appendix 6**.

The “Baseline ADS-B Performance Parameters” document contains three Tiers of service performance parameters with different reliability and availability standards for each Tier. The appropriate Tier should be selected for the type of ADS-B service intended:

- (a) Tier 1 standards are for a high performance traffic separation service;
- (b) Tier 2 standards are for a traffic situational awareness service with procedural separation; and
- (c) Tier 3 standards are for a traffic advisory service (flight information service)

To achieve high operational availability of ADS-B systems to support aircraft separation services, it is necessary to operate with duplicated/redundant systems. If one system fails, the service continues using an unduplicated system. This is acceptable for a short period, whilst the faulty system is being repaired, because the probability of a second failure during the short time window of repairing is low.

However, it is necessary to ensure that the repair does not take too long. A long repair time increases the risk of an unexpected failure (loss of service continuity); which in turn, introduces potential loss of service (low availability) and loss of aircraft operational efficiency and/or safety impacts.

Checklist of common items or parameters that could be considered for monitoring is summarized at Appendix 5 for reference.

8.1 Reliability

8.1.1 Reliability is a measure of how often a system fails and is usually measured as Mean Time Between Failure (MTBF) expressed in hours. Continuity is a measure equivalent to reliability, but expressed as the probability of system failure over a defined period. In the context of this document, failure means inability to deliver ADS-B data to the ATC centre. I.e: Failure of the ADS-B system rather than an equipment or component failure.

8.1.2 Poor system MTBF has a safety impact because typically it causes unexpected transition from one operating mode to another. For example, aircraft within surveillance coverage that are safely separated by a surveillance standard distance (say, 5 NM) are unexpectedly no longer separated by a procedural standard distance (say 15 mins), due to an unplanned surveillance outage.

8.1.3 In general, reliability is determined by design (see para 8.3 B below)

8.2 Availability

8.2.1 Availability is a measure of how often the system is available for operational use. It is usually expressed as a percentage of the time that the system is available.

8.2.2 Poor availability usually results in loss of economic benefit because efficiencies are not available when the ATC system is operating in a degraded mode (eg using procedural control instead of say 5 NM separation).

8.2.3 Planned outages are often included as outages because the efficiencies provided to the Industry are lost, no matter what the cause of the outage. However, some organisations do not include planned outages because it is assumed that planned outages only occur when the facility is not required.

8.2.4 Availability is calculated as

$$Availability (Ao) = MTBF / (MTBF + MDT)$$

where $MTBF$ = Mean Time Between SYSTEM Failure
 MDT = Mean Down Time for the SYSTEM

The MDT includes Mean Time To Repair (MTTR), Turn Around Time (TAT) for spares, and Mean Logistic Delay Time (MLDT)

NB: This relates to the failure of the system to provide a service, rather than the time between individual equipment failures. Some organisations use Mean Time Between Outage (MTBO) rather than MTBF.

8.2.5 Availability is directly a function of how quickly the SYSTEM can be repaired. Ie: directly a function of MDT. Thus availability is highly dependent on the ability & speed of the support organisation to get the system back on-line.

8.3 Recommendations for high reliability/availability ADS-B systems

A: **System design** can keep system failure rate low with long MTBF. Typical techniques are:

- to duplicate each element and minimise single points of failure. Automatic changeover or parallel operation of both channels keeps system failure rates low. Ie: the system keeps operating despite individual failures. Examples are :
 - Separate communication channels between ADS-B ground station and ATC centre preferably using different technologies or service providers eg one terrestrial and one satellite
- Consideration of Human factors in design can reduce the number of system failures due to human error. E.g. inadvertent switch off, incorrect software load, incorrect maintenance operation.
- Take great care with earthing, cable runs and lightning protection to minimise the risks of system damage
- Take great care to protect against water ingress to cables and systems
- Establish a system baseline that documents the achieved performance of the site that can be later be used as a reference. This can shorten troubleshooting in future.
- System design can also improve the MDT by quickly identifying problems and alerting maintenance staff. Eg Built in equipment test (BITE) can significantly contribute to lowering MDT.

B: Logistics strategy aims to keep MDT very low. Low MDT depends on logistic support providing short repair times. To achieve short repair times, ANSPs usually provide a range of logistics, including the following, to ensure that the outage is less than a few days:

- ensure the procured system is designed to allow for quick replacement of faulty modules to restore operations
- provide remote monitoring to allow maintainers to identify the faulty modules for transport to site
- provide support tools to allow technicians to repair faulty modules or to configure/setup replacement modules
- provide technicians training to identify & repair the faulty modules
- provide local maintenance depots to reduce the time it takes to access to the site
- provide documentation and procedures to “standardise” the process
- use an in-country spares pool to ensure that replacement modules are available within reasonable times
- use a maintenance contract to repair faulty modules within a specified turnaround time. I.e.: to replenish the spares pool quickly.

Whilst technical training and remote monitoring are usually considered by ANSPs, sometimes there is less focus on spares support.

Difficulties can be experienced if States :

- a) Fail to establish a spares pool – because procurement of spares at the time of failure can bring extensive delays due to :
- b) obtaining funds
- c) obtaining approval to purchase overseas
- d) obtaining approval to purchase from a “sole source”
- e) difficulties and delays in obtaining a quotation
- f) delays in delivery because the purchase was unexpected by the supplier
- g) Fail to establish a module repair contract resulting in :
 - long repair times
 - unplanned expenditure
 - inability for a supplier to repair modules because the supplier did not have adequate certainty of funding of the work

Spares pool

ANSPs can establish, preferably as part of their acquisition purchase, adequate spares buffer stock to support the required repair times. The prime objective is to reduce the time period that the system operates un-duplicated. It allows decoupling of the restoration time from the module repair time.

Module repair contract

ANSPs can also enter into a maintenance repair contract, preferably as part of their acquisition purchase, to require the supplier to repair or replace and deliver failed modules within a specified time – preferably with contractual incentives/penalties for compliance. Such support contracts are best negotiated as part of the acquisition contract when competition between vendors is at play to keep costs down. Sometimes it is appropriate to demand that the support contractor also keep a certain level of buffer stock of spares “in country”.

It is strongly recommended that maintenance support is purchased under the same contract as the

acquisition contract.

The advantages of a module repair contract are:

- The price can be determined whilst in the competitive phase of acquisition – hence avoids excessive costs
- The contract can include the supplier bearing all shipping costs
- Can be funded by a define amount per year, which support the budget processes. If the costs are fixed, the supplier is encouraged to develop a reliable system minimising module repairs.
- It avoids delays and funding issues at the time of the module failure

Other typical strategies are:

- Establish availability and reliability objectives that are agreed organization wide. In particular agree System response times (SRT) for faults and system failure to ensure that MDT is achieved. An agreed SRT can help organizations to decide on the required logistics strategy including number, location and skills of staff to support the system.
- Establish baseline preventative maintenance regimes including procedures and performance inspections in conjunction with manufacturer recommendations for all subsystems
- Use remote control & monitoring systems to identify faulty modules before travel to site. This can avoid multiple trips to site and reduce the repair time
- Have handbooks, procedures, tools available at the site or a nearby depot so that travel time does not adversely affect down time
- Have adequate spares and test equipment ready at a maintenance depot near the site or at the site itself. Vendors can be required to perform analysis of the number of spares required to achieve low probability of spare “stock out”
- Have appropriate plans to cope with system and component obsolescence. It is possible to contractually require suppliers to regularly report on the ability to support the system and supply components.
- Have ongoing training programs and competency testing to ensure that staff are able to perform the required role

The detailed set of operational and technical arrangements in place and actions required to maintain a system through the lifecycle are often documented in a Integrated Logistics Support Plan.

C: Configuration Management aims to ensure that the configuration of the ground stations is maintained with integrity. Erroneous configuration can cause unnecessary outages. Normally configuration management is achieved by :

- Having clear organizational & individual responsibilities and accountabilities for system configuration.
- Having clear procedures in place which define who has authority to change configuration and records of the changes made including, inter alia
 - The nature of the change including the reason
 - Impact of the change & safety assessment

- An appropriate transition or cutover plan
- Who approved the change
- When the change was authorized and when the change was implemented
- Having appropriate test and analysis capabilities to confirm that new configurations are acceptable before operational deployment.
- Having appropriate methods to deploy the approved configuration (Logistics of configuration distribution). Suggested methods;
 - Approved configuration published on intranet web pages
 - Approved configuration distributed on approved media

D: Training & Competency plans aim to ensure that staff has the skills to safety repairs Normally this is achieved by:

- Conduct of appropriate Training Needs Analysis (TNA) to identify the gap between trainee skill/knowledge and the required skill/knowledge.
- Development and delivery of appropriate training to maintainers
- Competency based testing of trainees
- Ongoing refresher training to ensure that skills are maintained even when fault rates are low

E: Data collection & Review :

Regular and scheduled review should be undertaken to determine whether reliability/availability objectives are being met. These reviews need to consider :

- Reports of actual achieved availability & reliability
- Data regarding system failures including “down time” needs to be captured and analysed so the ANSP actually knows what is being (or not being) achieved.
- Any failure trends that need to be assessed. This requires data capture of the root cause of failures
- Any environmental impacts on system performance, such coverage obstructions such as trees, planned building developments, corrosion, RFI etc. Changes in infrastructure may also be relevant including air conditioning (temperature/humidity etc.) and power system changes.
- System problem reports especially those that relate to software deficiencies (design)
- System and component obsolescence
- Staff skills and need for refresher training

9. ADS-B REGULATIONS AND PROCEDURES

9.1 INTRODUCTION

ADS-B involves the transmission of specific data messages from aircraft and vehicle systems. These data messages are broadcast at approximately 0.5 second intervals and received at compatible ground stations that relay these messages to ATSU(s) for presentation on ATS situation displays. The following procedures relate to the use of ADS-B data in ATS ground surveillance applications.

The implementation of the ADS-B system will support the provision of high performance surveillance, enhancing flight safety, facilitating the reduction of separation minima and supporting user demands such as user-preferred trajectories.

9.2 ADS-B REGULATIONS

As agreed at APANPRIG 22/8, States intending to implement ADS-B based surveillance services may designate portions of airspace within their area of responsibility by:

- (a) mandating the carriage and use of ADS-B equipment; or
- (b) providing priority for access to such airspace for aircraft with operative ADS-B equipment over those aircraft not operating ADS-B equipment.

In publishing ADS-B mandate/regulations, States should consider to :

- define the ADS-B standards applicable to the State. For interoperability and harmonization, such regulations need to define both the standards applicable for the aircraft ADS-B position source and the ADS-B transmitter.
- define the airspace affected by the regulations and the category of aircraft that the regulation applies to.
- define the timing of the regulations allowing sufficient time for operators to equip. Experience in Asia Pacific Regions is that major international carriers are having high equipage rates of ADS-B avionics. However the equipage rates of ADS-B avionics for some regional fleets, business jets and general aviation are currently low and more time will be required to achieve high equipage rates.
- establish the technical and operational standards for the ground stations and air traffic management procedures used for ADS-B separation services, including the associated voice communications services.

States may refer to Appendix 3 on the template for ADS-B mandate/regulations for aircraft avionics. Some States listed below have published their ADS-B mandate/regulations on their web sites that could also be used for reference.

(a) Civil Aviation Safety Authority (CASA) of Australia
Civil Aviation Order 20.18 Compilation No. 4) 2014, Civil Aviation Order 82.1 (Compilation No. 13) ,
Civil Aviation Order 82.3 (No. 18), Civil Aviation Order 82.5 (No. 19)
<https://www.legislation.gov.au/Details/F2017C01115/Download>”

(b) Civil Aviation Department (CAD) of Hong Kong, China
Aeronautical Information Publication Supplement No. A01/16 dated 1 February 2016
“https://www.ais.gov.hk/HK_AIP/supp/A01-16.pdf”

(c) Civil Aviation Authority of Singapore (CAAS)

Aeronautical Information Publication (eAIP) Part 2 ENR 1.8 – Regional Supplementary Procedures – Section 7 – Automatic Dependent Surveillance Broadcast (ADS-B) Out exclusive airspace within parts of the Singapore FIR

“<https://fpl-1.caasaim.gov.sg/aip/2018-03-14/final/2018-03-14/html/index-en-GB.html>”

(d) Federal Aviation Administration (FAA)

ADS-B Out Performance Requirements To Support Air Traffic Control (ATC) Service, Final Rule

<http://www.gpo.gov/fdsys/pkg/FR-2010-05-28/pdf/2010-12645.pdf>

States are encouraged to mandate forward fit for newly manufactured aircraft on and after 1 January 2020, having a maximum certified takeoff weight of 5700kg or greater, or having a maximum cruising true airspeed capability of greater than 250 knots, with ADS-B avionics compliant to Version 2 ES (equivalent to RTCA DO-260B) or later version².

9.3 FACTORS TO BE CONSIDERED WHEN USING ADS-B

9.3.1 Use of ADS-B Level data

The accuracy and integrity of pressure altitude derived level information provided by ADS-B are equivalent to Mode C level data provided through an SSR sensor and subject to the same operational procedures as those used in an SSR environment. Where the ATM system converts ADS-B level data to display barometric equivalent level data, the displayed data should not be used to determine vertical separation until the data is verified by comparison with a pilot reported barometric level.

9.3.2 Position Reporting Performance

The ADS-B data from the aircraft will include a NUCp/NIC/SIL/NACp categorization of the integrity and accuracy of the horizontal position data. This figure is determined from NIC/ NACp/ SIL values for DO260A/B compliant avionics and NUC values for DO260/ED102 compliant avionics.

In general, for 5NM separation, if the HPL value used to generate ADS-B quality indicators (NUC or NIC) is greater than 2 nautical miles the data is unlikely to be of comparable quality to that provided by a single monopulse SSR. ADS-B data should not be used for separation unless a suitable means of determining data integrity is used.

The key minimum performance requirements for an ADS-B system to enable the use of a 3 NM or 5 NM separation minimum in the provision of air traffic control is provided in the ICAO Circular 326 (especially Appendix C).

ADS-B reports with low integrity may be presented on situation displays, provided the controller is alerted (e.g. by a change in symbology and/or visual alert) to the change and the implications for the provision of separation. An ANS Provider may elect not to display ADS-B tracks that fail to meet a given position reporting performance criterion.

9.3.3 GNSS Integrity Prediction Service

² Subject to endorsement by CNS/SG/22 in July 2018

ADS-B uses GNSS for position determination. As such, availability of GNSS data has a direct influence on the provision of a surveillance service.

ATS Providers may elect to use a GNSS integrity prediction service to assist in determining the future availability of useable ADS-B data. The integrity prediction service alerts users to potential future loss or degradation of the ADS-B service in defined areas. When these alerts are displayed, the system is indicating to its users that at some time in the future the ADS-B positional data may be inadequate to support the application of ADS-B separation. It is recommended that the prediction service is made available to each ATSU that is employing ADS-B to provide a separation service, to ensure that air traffic controllers are alerted in advance of any predicted degradation of the GNSS service and the associated reduction in their ability to provide ADS-B separation to flights that are within the affected area. This is similar to having advance warning of a planned radar outage for maintenance.

ADS-B should not be used to provide separation between aircraft that will be affected by an expected period of inadequate position reporting integrity.

If an unpredicted loss of integrity occurs (including a RAIM warning report from aircrew) then;

- (a) ADS-B separation should not be applied by ATC to the particular aircraft reporting until the integrity has been assured; and
- (b) The controller should check with other aircraft in the vicinity of the aircraft reporting the RAIM warning, to determine if they have also been affected and establish alternative forms of separation if necessary.

9.3.4 Sharing of ADS-B Data

ADS-B Data-sharing for ATC Operations

Member States should consider the benefits of sharing ADS-B data received from aircraft operating in the proximity of their international airspace boundaries with adjacent States that have compatible technology in an effort to maximize the service benefits and promote operational safety.

Data sharing may involve the use of the data to provide separation services if all the requirements for delivery of separation services are satisfied. In some cases, States may choose to use a lower standard that supports surveillance safety nets and situational awareness whilst operations are conducted using procedural separation standards.

Any agreement on the sharing of surveillance data should be incorporated in Letters of Agreement between the States concerned. Such agreements may also include the sharing of VHF communication facilities.

A template for ADS-B data-sharing agreement is provided on the ICAO APAC website “<http://www.icao.int/APAC/Pages/edocs.aspx>” for reference by States.

ADS-B Data-sharing for Safety Monitoring

With endorsement of the methodology by both the ICAO Separation and Airspace Safety Panel (SASP) and the Regional Airspace Safety Monitoring Advisory Group (RASMAG), ADS-B data can be used for calculating the altimetry system error (ASE) which is a measure of the height-keeping performance of an aircraft. It is an ICAO requirement that aircraft operating in RVSM airspace must undergo periodic monitoring on height-keeping performance. The existing methods to estimate aircraft ASE include use of a portable device, the Enhanced GPS

Monitoring Unit, and ground-based systems called Height Monitoring Unit/Aircraft Geometric Height Measurement Element. The use of ADS-B data for height-keeping performance monitoring, on top of providing enhanced and alternative means of surveillance, will provide a cost-effective option for aircraft operators. States are encouraged to share ADS-B data to support the height-keeping performance monitoring of airframe.

Civil/Military ADS-B Data-sharing

Civil/military data sharing arrangements, including aircraft surveillance, were a key part of civil/military cooperation in terms of tactical operational responses and increasing trust between civil and military units.

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.

Some military transponders may support ADS-B using encrypted DF19 messages, but these data are normally not decoded or used at all by civil systems. In most cases today, tactical military aircraft are not ADS-B equipped or could choose to disable transmissions. In future, increasing numbers of military aircraft will be ADS-B capable, with the ability to disable these transmissions. ADS-B data sharing should not influence the decision by military authorities 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 are near the boundary.

A guidance material on advice to military authorities regarding ADS-B data sharing is provided on the ICAO APAC website “<http://www.icao.int/APAC/Pages/edocs.aspx>” for reference by States.

9.3.5 Synergy of ADS-B and GNSS

States intending to implement GNSS/PBN or ADS-B should consider the efficiency of implementing the other technology at the same time due to the inherent efficiencies in doing so. GNSS systems provide navigation solutions to IFR aircraft for the conduct of enroute, terminal and non-precision approaches. The use of GNSS/PBN can provide higher performance and higher safety. Transition to GNSS can avoid significant ground infrastructure costs.

ADS-B systems provide surveillance based upon GNSS position source. ADS-B provides high performance and high update surveillance for both air-air and ATC surveillance. Transition to ADS-B can avoid the costs associated with ground based radar infrastructure. ADS-B system installations rely on acceptable GNSS equipment being installed in the aircraft to provide the position source and integrity.

If the fleet is equipped with ADS-B, they will already have most of the requirements to use GNSS for navigation satisfied. Similarly, if aircraft have suitable GNSS on board, they will have a position source to support ADS-B. It is noted however, that some care is needed to ensure that the requirements of GNSS/PBN and surveillance are both satisfied.

There is significantly less cost for these systems to be installed in an aircraft at the same time. A single installation of GNSS & ADS-B will involve :

- a single design activity instead of two
- a single downtime instead of two

- installation of the connection between GPS and ADS-B transponder
- a single test, certification and aircraft flight test

For the affected aviation community (ANSP, regulator and operator), the lessons learnt and issues faced in both GNSS and ADS-B have significant commonality. This can lead to efficiencies in Industry education and training.

9.3.6 Use of ADS-B for Airport Surface Movement

Both DO321/ED-163 and the EUROCONTROL guidance for the provision of ATS using ADS-B for Airport Surface Movement state the horizontal position accuracy needs to be ≤ 10 meters at 95%, which translates into a positional accuracy of NACp = 10.

However, most of the currently deployed GNSS horizontal position sources provide values leading to either a NACp = 9 (30 meters) or a NACp = 8 (92 meters), whilst the actual position accuracy could reach 2 to 3 meters. Provided that the position source is GNSS-based, States can consider to use the following ADS-B quality indicators to determine the horizontal positional accuracy:

- DO260
 - NUCp > 6
- DO260A
 - NACp ≥ 8
 - NIC > 0
 - SIL = 2
- DO260B
 - NACp ≥ 8
 - NIC > 0
 - SIL = 3

Guidance documents recommend implementing some form of horizontal positional accuracy monitoring for using ADS-B positional data with accuracy down to NUCp > 6 or NACp ≥ 8 for airport surface movement. Visual monitoring by controllers of vehicles on taxiways and runways can be considered as an initial monitoring of the horizontal positional accuracy within the airport. In addition, States can consider to evaluate the performance of ADS-B tracks against reference tracks from proven surveillance systems, e.g. tracks from MLAT systems with certified accuracy, to show that ADS-B data is suitable for ground surveillance and falls within the requirements of international standards.

For ADS-B only tracks with quality indicators below the required accuracy, States are encouraged to keep the display of the tracks in the surveillance display with due discrimination on the track symbols in order to enhance the situation awareness of controllers.

9.3.7 1090 Mhz Spectrum and 24-bit Aircraft Address Issue with Unmanned Aircraft Systems (UAS)

Proper and efficient utilization of available bandwidth and capacity at 1 090 MHz is a key element to ensure the safe and reliable operation of aeronautical surveillance systems, including secondary surveillance radar (SSR), automatic dependent surveillance broadcast (ADS-B) and airborne collision avoidance systems (ACAS). Studies conducted by ICAO expert groups have identified certain issues and potential technical concerns to the operation of these surveillance systems in the presence of large numbers of unmanned aircraft (UA), if those UA are equipped with an ADS-B OUT transmitter on 1 090 MHz and operating at very low levels.

Recognizing issues associated with those UA which may adversely affect safety for all aircraft in the area, ICAO has developed guidance material (see Appendix 8) to assist States in validating the utilization of 1 090 MHz and for withholding 24-bit aircraft addresses to UA unless certain criteria have been met. States are encouraged to make use of the guidance material as well as any other related provisions to ensure that the surveillance capabilities being provided by the aforementioned surveillance systems.

9.3.8 Methodologies to Avoid or Reduce 1090MHz Congestion

- Make periodic measurements, say every few years so that the environment status is known.
- Reduce the number of SSR radars, especially non Monopulse and Mode A/C radars if operationally viable.
 - Convert Mode A/C to either ADS-B or Mode S
 - Some Secondary surveillance radars can be replaced by using ADS-B. e.g.: Australia removed 2 radars in the last decade in favor of ADS-B.
 - Complement existing coverage with Space based ADS-B
- Use Monopulse radars instead of old conventional radars so that the interrogation rate can be reduced
- Minimise the interrogation rate from radars and active multilateration consistent with the operational objective
- Decommission old Mode A/C radars because they allow multiple aircraft to reply to all interrogations
- Implement radar interrogation patterns to only interrogate on azimuths where additional surveillance is warranted.
- Minimise “all call” rate commensurate with operational needs
- Reduce interrogation transmit power to the minimum needed for the operational objective. Some systems allow this to be changed on different azimuths
- Avoid or reduce active multilateration if possible, and minimize transmit power commensurate with the operational objective
 - Mandate ADS-B fitment in aircraft: Multilateration position can be determined using the DF17 ADS-B message if required, so no interrogation is required
 - Gradually mandate Mode S in aircraft so that the need to interrogate Mode A/C transponders is removed eventually. Multilateration position can be determined using the DF11 message if required. A mode S interrogation still required for altitude and identity to be obtained. Mode S interrogation only triggers a single aircraft to reply.
 - Aircraft with mode A/C transponders (without Mode S require or ADS-B) require multiple interrogations with typically an omni directional antenna which makes all such aircraft to reply.
- Replace or reduce any nav aids (e.g. DME/TACAN, ICAO standard or non ICAO standard) that impinge on the 1090 MHz channel.
- Close any illegal transmissions affecting the 1090MHz band
- Take care with DAPS interrogation to ensure only wanted data is requested

9.4 Reporting Rates

9.4.1 General

The ADS-B system shall maintain a reporting rate that ensures at least an equivalent degree of accuracy, integrity and availability as specified by the performance requirements of a radar system that is used to provide a similar ATC service. The standard reporting rate is approximately 0.5 second from the aircraft, but the rate of update provided to the ATM system (for the situation display) may be less frequent (e.g. 5 seconds), provided performance requirements for the service are achieved. Reporting rate requirements are included in the document “Baseline ADS-B Service Performance Parameters” which is available at Appendix 6.

9.5 SEPARATION

9.5.1 General

ADS-B data may be used in combination with data obtained by other means of surveillance (such as radar, flight plan track, ADS-C) for the application of separation provided appropriate minima as determined by the State are applied. It should be noted that the quality of communications will have a bearing on the determination of appropriate minima.

All safety net features (MSAW, STCA, MTCA, RAM and DAIW/ RAI etc) should possess the same responsiveness as equivalent radar safety net features.

9.5.2 Identification Methods

Some of the methods approved by ICAO for establishing identification with radar, may be employed with ADS-B (see PANS-ATM chapter 8). One or more of the following identification procedures are suggested:

- a) direct recognition of the aircraft identification in an ADS-B label on a situation display;
- b) transfer of ADS-B identification;
- c) observation of compliance with an instruction to TRANSMIT ADS-B IDENT.

Note: In automated systems, the “IDENT” feature may be presented in different ways, e.g. as a flashing of all or part of the position indication and associated label.

9.5.3 ADS-B Separation

ADS-B Separation minima has been incorporated by ICAO in PANS-ATM (Doc 4444), and in Regional Supplementary Procedures (Doc 7030).

In a mixed surveillance environment, States should use the larger separation standard applicable between aircraft in the conflict pair being considered.

9.5.4 Vertical separation

9.5.4.1 Introduction

The ADS-B level data presented on the controllers situation display shall normally be derived from barometric pressure altitude. In the event that barometric altitude is

absent, geometric altitude shall not be displayed on displays used for provision of air traffic services. Geometric altitude may be used in ATM systems for other purposes.

9.5.4.2 Vertical tolerance standard

The vertical tolerances for ADS-B level information should be consistent with those applied to Mode C level information.

9.5.4.3 Verification of ADS-B level information

The verification procedures for ADS-B level information shall be the same as those employed for the verification of Mode C level data in a radar environment.

9.6 AIR TRAFFIC CONTROL CLEARANCE MONITORING

9.6.1 General

ADS-B track data can be used to monitor flight path conformance with air traffic control clearances.

9.6.2 Deviations from ATC clearances

The ATC requirements relating to monitoring of ADS-B traffic on the situation display should be similar to those contained in PANS-ATM Ch.8.

9.7 ALERTING SERVICE

For ADS-B equipped aircraft, the provision of an alerting service should be based on the same criteria as applied within a radar environment.

9.8 POSITION REPORTING

9.8.1 Pilot position reporting requirements in ADS-B coverage

States should establish voice and/or CPDLC position reporting procedures consistent with those applicable with radar for aircraft that have been identified by ATC.

9.8.2 Meteorological reporting requirements in ADS-B airspace

ATSUs may promulgate in the AIP meteorological reporting requirements that apply within the nominated FIR. The meteorological reporting data required and the transmission methods to be used by aircrew shall be specified in AIP.

9.9 PHRASEOLOGY

9.9.1 Phraseology Standard

States should use common phraseology for both ADS-B and radar where possible, and should note the requirement for ADS-B specific phraseology in some instances. States shall refer to PANS ATM Chapter 12 for ADS-B phraseology:

ADS-B EQUIPMENT DEGRADATION

ADS-B OUT OF SERVICE (appropriate information as necessary).

TO REQUEST THE CAPABILITY OF THE ADS-B EQUIPMENT

a) ADVISE ADS-B CAPABILITY;

*b) ADS-B TRANSMITTER (data link);

*c) ADS-B RECEIVER (data link);

*d) NEGATIVE ADS-B.

* Denotes pilot transmission.

Note: For (b) and (c) – the options are not available for aircraft that are not equipped.

TO REQUEST RESELECTION OF AIRCRAFT IDENTIFICATION
REENTER FLIGHT IDENTIFICATION.

Note: For some aircraft, this option is not available in-flight

TERMINATION OF RADAR AND/OR ADS-B SERVICE
IDENTIFICATION LOST [reasons] (instructions).

TO REQUEST THE OPERATION OF THE MODE S OR ADS-B IDENT FEATURE
SQUAWK IDENT.

Note: For some standalone ADS-B equipage affecting General Aviation, the option of
“TRANSMIT ADS-B IDENT” may be available

TO REQUEST AIRCRAFT SWITCHING TO OTHER TRANSPONDER OR TERMINATION
OF ADS-B TRANSMITTER OPERATION

- a) SWITCH TO OTHER TRANSPONDER
- b) STOP ADS-B TRANSMISSION. SQUAWK (code) ONLY.

Note:

a) In many cases the ADS-B transmitter cannot be operated independently of the SSR transponder and switching off the ADS-B transmission would also switch off the SSR transponder operation

b) “STOP ADS-B TRANSMISSION” applies only to aircraft that have the facility to switch off the ADS-B transmission, while maintaining SSR operation.

9.9.2 Operations of Mode S Transponder and ADS-B

It should be noted that independent operations of Mode S transponder and ADS-B will not be possible in many aircraft (e.g. where ADS-B is solely provided by 1090 MHz extended squitter emitted from the transponder). Additionally, some desirable but optional features of ADS-B transmitters may not be fitted in some aircraft. Controller training on this issue, as it relates to the following examples of radio telephony and/or CPDLC phraseology is recommended.

9.9.2.1 STOP ADSB TRANSMISSION or STOP SQUAWK

Issue: In most commercial aircraft, a common “transponder control head” is used for SSR transponder, ACAS and ADS-B functionality. In this case, a pilot who complies with the instruction to stop operation of one system will also need to stop operation of the other systems – resulting in a loss of surveillance not intended or expected by the controller.

ATC need to be aware that an instruction to “Stop ADS-B Transmission” may require the pilot to switch off their transponder that will then stop all other functions associated with the transponder operations (such as ACARs etc). Pilots need to be aware of their aircraft’s equipment limitations, the consequences of complying with this ATC instruction, and be aware of their company policy in regard to this. As with any ATC instruction issued, the pilot should advise ATC if they are unable to comply.

Recommendation: It is recommended that the concatenated phrases STOP ADSB TRANSMISSION, SQUAWK (code) ONLY or STOP SQUAWK, TRANSMIT ADSB ONLY are used. It is recommended that controller training highlights the possible consequences of **issuing** these instructions and that pilot training highlights the consequences of **complying** with this instruction. It is also recommended that aircraft operators have a clearly stated policy on procedures for this situation. Should a pilot respond with UNABLE then the controller should consider alternative solutions to the problem that do not remove the safety defences of the other surveillance technologies. This might include manual changes to flight data, coordination with other controllers and/or change of assigned codes or callsigns.

Very few aircraft provide the capability to turn off ADS-B without turning off TCAS. It is not recommended to switch off ATC transponders (& remove TCAS protection). The only action for most

pilots of aircraft transmitting misleading ADS-B data in response to ATC requests is to recycle the transponder, or switch to the alternate transponder as appropriate. Besides, aircraft that do not support ADS-B OFF should have the details included in the flight manual including the undesirability of disabling TCAS.

9.9.2.2 STOP ADSB ALTITUDE TRANSMISSION [WRONG INDICATION or reason] and TRANSMIT ADSB ALTITUDE

Issue: Most aircraft will not have separate control of ADSB altitude transmission. In such cases compliance with the instruction may require the pilot to stop transmission of all ADSB data and/or Mode C altitude – resulting in a loss of surveillance not intended or expected by the controller.

Recommendation: It is recommended that, should the pilot respond with UNABLE, the controller should consider alternative solutions to the problem that do not remove the safety defences of other surveillance data. This might include a procedure that continues the display of incorrect level information but uses pilot reported levels with manual changes to flight data and coordination with other controllers.

9.9.2.3 TRANSMIT ADS-B IDENT

Issue: Some aircraft may not be capable or the ADSB SPI IDENT control may be shared with the SSR SPI IDENT function.

Recommendation: It is recommended that controllers are made aware that some pilots are unable to comply with this instruction. An alternative means of identification that does not rely on the ADSB SPI IDENT function should be used.

9.10 FLIGHT PLANNING

9.10.1 ADS-B Flight Planning Requirement – Flight Identity

The aircraft identification (ACID) must be accurately recorded in section 7 of the ICAO Flight Plan form as per the following instructions:

Aircraft Identification, not exceeding 7 characters 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 three-letter designator for the aircraft operating agency followed by the flight identification (e.g. KLM511, BAW213, JTR25), when:

in radiotelephony the callsign used consists of the ICAO telephony designator for the operating agency followed by the flight identification (e.g. KLM 511, SPEEDBIRD 213, HERBIE 25).

Or,

- b) The registration marking of the aircraft (e.g. EIAKO, 4XBCD, OOTEK), when:
 - 1) in radiotelephony the callsign used consists of the registration marking alone (e.g. EIAKO), or preceded by the ICAO telephony designator for the operating agency (e.g. SVENAIR EIAKO),

- 2) the aircraft is not equipped with 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 PANS-ATM refers. ICAO designators and telephony designators for aircraft operating agencies are contained in ICAO Doc 8585.

9.10.2 ADS-B Flight Planning Requirements

9.10.2.1 ICAO Flight Plan Item 10 – Surveillance Equipment and Capabilities

An appropriate ADS-B designator shall be entered in item 10 of the flight plan to indicate that the flight is capable of transmitting ADS-B messages.

These are defined in ICAO DOC 4444 as follows:

- B1 ADS-B with dedicated 1090 MHz ADS-B “out” capability
- B2 ADS-B with dedicated 1090 MHz ADS-B “out” and “in” capability
- U1 ADS-B “out” capability using UAT
- U2 ADS-B “out” and “in” capability using UAT
- V1 ADS-B “out” capability using VDL Mode 4
- V2 ADS-B “out” and “in” capability using VDL Mode 4

During the ADS-B SITF/13 meeting held in April 2014, clarification of the B1 and B2 descriptors was recommended as follows. This will be progressed for change to ICAO DOC 4444, but may take some time for formal adoption:

- B1 ADS-B “out” capability using 1090 MHz extended squitter
- B2 ADS-B “out” and “in” capability using 1090 MHz extended squitter

States should consider use of the revised descriptors in AIP.

9.10.2.2 ICAO Flight Plan Item 18 – Other Information

Where required by the appropriate authority the ICAO Aircraft Address (24 Bit Code) may be recorded in Item 18 of the ICAO flight plan, in hexadecimal format as per the following example:

CODE/7C432B

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.

9.10.2.3 Transponder Capabilities

When an aircraft is equipped with a mode S transponder, that transmits ADS-B messages, according to ICAO Doc 4444, an appropriate Mode S designator should also be entered in item 10; i.e.: either

- E Transponder — Mode S, including aircraft identification, pressure-altitude and extended squitter (ADS-B) capability, or
- L Transponder — Mode S, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability.

During the ADS-B SITF/13 meeting held in April 2014, clarification of the E and L descriptors was recommended as follows. This will be progressed for change to ICAO DOC 4444, but may take some time for formal adoption:

- E Transponder — Mode S, including aircraft identification, pressure-altitude and ADS-B capability, or
- L Transponder — Mode S, including aircraft identification, pressure-altitude, ADS-B and enhanced surveillance capability.

States should consider use of the revised descriptors in AIP.

9.10.2.4 Inconsistency between ADS-B Flight Planning and Surveillance Capability

Inconsistency between flight planning of ADS-B and surveillance capability of an aircraft can impact on 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. An example of such advice is provided at Appendix 4.

9.10.3 Setting Aircraft Identification (Flight ID) in Cockpits

(a) Flight ID Principles

The aircraft identification (sometimes called the flight identification or FLTID) is the equivalent of the aircraft callsign and is used in both ADS-B and Mode S SSR 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 and aircraft on a display and to correlate a radar or ADS-B track with the flight plan data. Aircraft identification is critical, so it must be entered carefully. Punching in the wrong characters can lead to ATC confusing one aircraft with another.

It is important that the identification exactly matches the aircraft identification (ACID) entered in the flight notification.

Intuitive correlation between an aircraft's identification and radio callsign enhances situational awareness and communication. Airline aircraft typically use a three letter ICAO airline code used in flight plans, NOT the two letter IATA codes.

(b) Setting Flight ID

The callsign dictates the applicable option below for setting ADS-B or Mode S Flight ID:

- (i) 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).
- (ii) 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).
- (iii) The registration mark alone of the aircraft if the callsign is the abbreviated version of the registration (eg ABC for domestic operations).
- (iv) The designator corresponding to a particular callsign approved by the ANSP or regulator (e.g. SPTR13 for firepotter 3).
- (v) 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).

9.11 PROCEDURES TO HANDLE NON-COMPLANT ADS-B AIRCRAFT OR MIS-LEADING ADS-B TRANSMISSIONS

ADS-B technology is increasingly being adopted by States in the Asia/Pacific Region. Asia/Pacific Region adopted 1090 extended squitter technology. Reliance on ADS-B transmissions can be expected to increase over the coming years.

Currently a number of aircraft are transmitting ADS-B data which is misleading or non-compliant with the ICAO standards specified in Annex 10. Examples include:

- a) aircraft broadcasting incorrect message formats;
- b) aircraft broadcasting inertial positional data and occasionally indicating in the messages that the data has high integrity when it does not;
- c) using GPS sources that do not generate correct integrity data, whilst indicating in the messages that the data has high integrity;
- d) transmitting ADS-B data with changing (and incorrect) flight identity; and
- e) transmitting ADS-B data with incorrect flight identity continuously.

If the benefits of ADS-B are to flow to the aviation industry, misleading and non-compliant ADS-B transmissions need to be curtailed to the extent possible.

The transmission of a value of zero for the NUCp or the NIC or the NACp or the SIL by an aircraft indicates a navigational uncertainty related to the position of the aircraft or a navigation integrity issue that is too significant to be used by air traffic controllers.

As such, the following procedure currently stipulated in the Regional Supplementary Procedures Doc 7030³, shall be applicable in the concerned FIRs on commencement of ADS-B based surveillance services notified by AIP or NOTAM:

If an aircraft operates within an FIR where ADS-B-based ATS surveillance service is provided, and

- a) carries 1090 extended squitter ADS-B transmitting equipment which does not comply with one of the following:
 - 1) EASA AMC 20-24; or
 - 2) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia; or
 - 3) installation in accordance with the FAA AC No. 20-165 – Airworthiness Approval of ADS-B; or
- b) the aircraft ADS-B transmitting equipment becomes unserviceable resulting in the aircraft transmitting misleading information;

then:

³ SURICG/2 recommended States/Administrations to update their ADS-B Avionics Equipage Requirements to align with the template in Appendix 3

a) except when specifically authorized by the appropriate ATS authority, the aircraft shall not fly unless the equipment is:

- 1) deactivated; or
- 2) transmits only a value of zero for the NUCp or NIC or NACp or SIL

States may elect to implement a scheme to blacklist those non-compliant aircraft or aircraft consistently transmitting mis-leading ADS-B information, so as to refrain the aircraft from being displayed to ATC. Please refer Appendix 2 for guidance in implementing the blacklist scheme.

A sample template is given below for reference by States to publish the procedures to handle non-compliant ADS-B aircraft or misleading ADS-B transmissions in their ADS-B mandate/regulations:

After <insert earliest date that ADS-B may be used for any relevant operational purpose> if an aircraft carries ADS-B transmitting equipment which does not comply with :

- (a) 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
- (b) 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
- (c) Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems, or
- (d) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.

or the aircraft ADS-B transmitting equipment becomes unserviceable resulting in the aircraft transmitting misleading information;

the aircraft must not fly unless equipment is:

- (a) deactivated; or
- (b) set to transmit only a value of zero for the NUCp or NIC or NACp or SIL.

Note:

1. It is considered equivalent to deactivation if NUCp or NIC or NACp or SIL is set to continually transmit only a value of zero.
2. Regulators should take appropriate action to ensure that such regulations are complied with.
3. ATC systems should discard ADS-B data when NUC or NIC or NACp or SIL =0.

9.12 EMERGENCY PROCEDURES

ATC surveillance systems should provide for the display of safety-related alerts and warnings, including conflict alert, minimum safe altitude warning, conflict prediction and unintentionally duplicated SSR codes and aircraft identifications.

The ADS-B avionics may transmit emergency status messages to any ADS-B ground station within coverage. The controller receiving these messages should determine the nature of the emergency, acknowledge receipt if appropriate, and initiate any assistance required. An aircraft equipped with ADS-B might operate the emergency and/or urgency mode as follows:

- a) emergency;
- b) no communications;
- c) unlawful interference;
- d) minimum fuel; and/or
- e) medical.

Selection of an emergency transponder code (e.g. 7600) automatically generates an emergency indication in the ADS-B message. However, some ADS-B transponders may only generate a generic emergency indication. That means, the specific type of emergency, e.g., communication failure, is not always conveyed to the controller in an ADS-B environment. The controller may only receive a generic emergency indication irrespective of the emergency codes being selected by the pilot.

In some early ADS-B avionics configurations, when a generic emergency indication is being transmitted, a request to “Transmit ADS-B Ident” or “Squawk Ident” may not result in the Ident indication being displayed in the ATC System. This is because the emergency and ident flags share the same data elements in the ADS-B downlink message.

Due to limitations of some ADS-B transponders, procedures should be developed for ATC to confirm the types of emergency with pilots based on operational needs of States.

In contrast to DO260 avionics, for DO-260A avionics, the transmission of an Emergency/Priority status message in the ADS-B message set will also include the original MODE A code allocated by ATC. When the aircraft resets the MODE A code to the original allocated code the ground station can retain the Emergency/Priority status in the Asterix message, for up to 100 seconds, even though the aircraft is no longer squawking an emergency code. This situation can generate confusion as to the actual status of the aircraft.

Executive control responsibility

The responsibility for control of the flight rests with the ATSU within whose airspace the aircraft is operating. However, if the pilot takes action contrary to a clearance that has already been coordinated with another sector or ATSU and further coordination is not possible in the time available, the responsibility for this action would rest with the pilot in command, and performed under the pilot’s emergency authority.

Emergency procedures

The various circumstances surrounding each emergency situation preclude the establishment of exact detailed procedures to be followed. The procedures outlined in PANS-ATM Chapter 15 provide a general guide to air traffic services personnel and where necessary, should be adapted for the use of ADS-B.

9.13 PROCEDURES TO HANDLE GPS TIME AND WEEK COUNTER ROLLOVER

The GPS system is often used in the ATC environment, including:

- to time stamp surveillance data with the “time of applicability” of the data. This allows positional data to be “extrapolated” to the time of display and allows old data to be discarded.
- to time synchronise ATC systems to the correct time, so that when it uses surveillance data, it can determine the “age” of the data.
- to time stamp recorded data and maintenance data

Thus accurate time is important to minimise incorrect positional data being presented to ATC and to ensure that valid data is not discarded – amongst other important technical roles in synchronising various computer servers in a network.

9.13.1 GPS TIME – COUNTERS AND LEAP SECONDS

The GPS navigation message contains information about the current date and time in the form of a sequential week counter (representing the number of weeks elapsed since the last time this counter was reset to zero). This counter is 10 bits long and this resets to zero every 1024 weeks (19.6 years). GPS week zero started at 00:00:00 UTC on January 6, 1980, and the week number became zero again on August 21, 1999. A rollover event occurred on 6 April 2019.

ATC systems use UTC. The difference between GPS time and UTC changes whenever a “leap second” is inserted in UTC. Wikipedia says that “one-second adjustment that is occasionally applied to civil time Coordinated Universal Time (UTC) to keep it close to the mean solar time at Greenwich, in spite of the Earth's rotation slowdown and irregularities”. This is done in coordination with the international community.

The GPS messages sent by the satellites includes the difference between GPS time and UTC, thus allowing the GPS receivers to calculate UTC.

9.13.2 GPS RECEIVER ISSUES

Each GPS receiver has firmware/software that computes UTC from the GPS time counters and from the known offset. In the past some GPS receivers have not coped well with these changes. The triggers occur very infrequently and in some cases they have not been adequately tested.

This can cause incorrect UTC time to be output following some events such as:

- Software deficiencies highlighted by the week number rollover. The rollover occurs each 19.6 years
- Deficiencies at leap second introductions (at intervals greater than 1 year)
- Loss of GPS-UTC time offset (sometimes at power off in devices not using non-volatile storage). Typically this can result in up to 15 minutes of incorrect time data until the offset is restored from the satellite messages.

Other problems such as receiver lock up (service failure) can occur when the GPS receiver is exposed to rare real world events or stimuli.

9.13.3 ATC SYSTEM RISKS AND MITIGATION

ANSPs and regulators need to be aware of the potential issues that may arise from GPS receivers that inadequately process events and stimuli.

Possible mitigations that could be considered include:

- Testing GPS receivers with a GPS test tool that simulates possible events/ stimuli
- Co-ordination with GPS receiver manufacturers
- Disconnect GPS receivers just before expected events – and check the output before reconnecting the GPS receiver. (in this case the ANSP would be relying on the ability of the ATC or surveillance system to operate for a period without the GPS synchronisation).

10. SECURITY ISSUES ASSOCIATED WITH ADS-B

10.1 INTRODUCTION

ADS-B technologies are currently “open systems” and the openness is an essential component of successful use of ADS-B. It was also noted that ADS-B transmission from commercial aircraft is a “fact of life” today. Many commercial aircraft are already equipped with ADS-B and have been transmitting data for some time.

It was noted that there has been considerable alarmist publicity regarding ADS-B security. To a large extent, this publicity has not considered the nature and complexity of ATC. Careful assessment of security policies in use today for ADS-B and other technologies can provide a more balanced view.

10.2 CONSIDERATIONS

A list of ADS-B vulnerabilities categorised into threats to Confidentiality, Integrity and Availability has been reviewed and documented into the guidance material on security issues associated with ADS-B provided on the ICAO APAC website “<http://www.icao.int/APAC/Pages/edocs.aspx>” under “Restricted Site” for reference by States. States could contact ICAO Regional Office to get access to the guidance material. The following recommendations are made to States :

- (a) While ADS-B is recognized as a key enabling technology for aviation with potential safety benefits, it is recommended that States made aware of possible ADS-B security specific issues;
- (b) It is recommended that States note that much of the discussion of ADS-B issues in the Press has not considered the complete picture regarding the ATC use of surveillance data;
- (c) For current ADS-B technology implementation, security risk assessment studies should be made in coordination with appropriate national organisations and ANSPs to address appropriate mitigation applicable in each operational environment, in accordance with ATM interoperability requirements; and
- (d) Future development of ADS-B technology, as planned in the SESAR master plan for example, should address security issues. Studies should be made to identify potential encryption and authentication techniques, taking into consideration the operational need of air to ground and air to air surveillance applications. Distribution of encryption keys to a large number of ADS-B receivers is likely to be problematic and solutions in the near and medium term are not considered likely to be deployed worldwide. Internet based encryption strategies are not deployable when ground stations are pass receivers.

10.3 MEASURES FOR ENHANCING THE SECURITY OF ADS-B

10.3.1 TIME DIFFERENCE OF ARRIVAL (TDOA) BASED POSITION VERIFICATION METHOD

One of the technologies for enhancing ADS-B security is TDOA-based position verification, which is able to mitigate false targets caused by spoofing. In a case of spoofing, the position of the emitter (attacker) is likely to differ from the position contained in the ADS-B signal. Such positional difference can be detected by means of TDOA.

When an emitter (aircraft or spoofing emitter) transmits an ADS-B signal, (at least) two receivers detect the signal and measure the time of arrival (TOA). The difference of the TOAs between the two receivers is a TDOA. Next, decoding the ADS-B signal obtains the position

contained in the signal. A calculation using the ADS-B position and the known receiver positions obtains the expected TDOA.

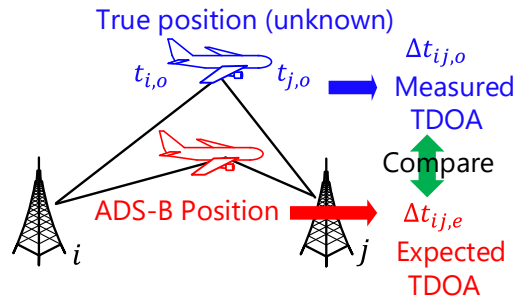


Figure 10.3.1.1 Illustration of the Procedures of TDOA method

The measured and expected TDOAs are compared. The TDOA difference is large in a case of spoofing and small in a case of a legitimate aircraft, as illustrated in Figure 10.3.1.2 (a) and (b), respectively. Therefore, a threshold can be used to make a decision; if the TDOA difference is smaller than the threshold, the position is determined as valid. If the TDOA difference is larger than the threshold, the position is determined as anomalous (spoofing).

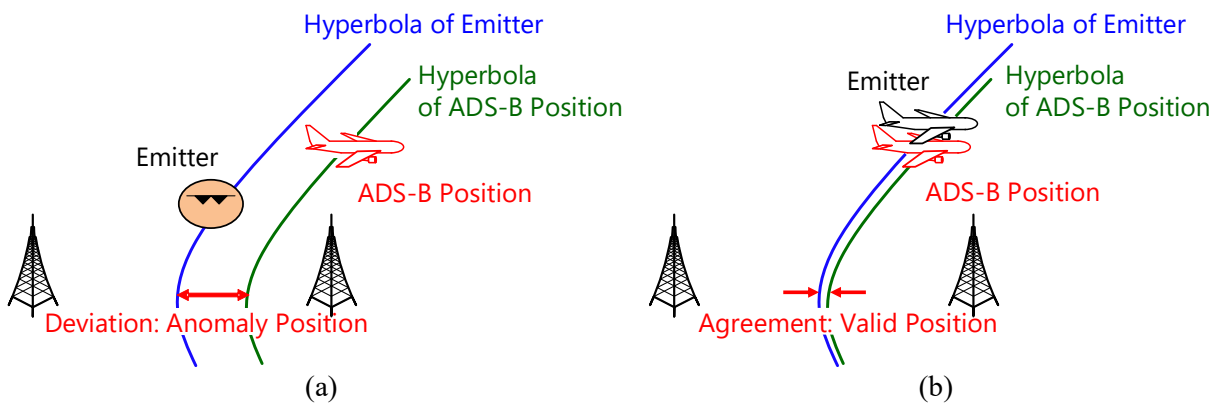


Figure 10.3.1.2 Illustration of (a) case of spoofing, and (b) case of legitimate aircraft

10.3.2 APPROPRIATE IMPLEMENTATION OF A DECODING METHOD OF CPR

CPR (Compact Position Reporting) is the format used to encode a latitude and longitude in the ADS-B position report using 1090 Extended Squitter (DF = 17, BDS = 0,5 and 0,6). There are two ways of decoding the encoded CPR:

- a) globally unambiguous decoding, which requires two signals called “even” and “odd”.
- b) locally unambiguous decoding, which requires either even or odd signal plus a reference position.

Appropriate implementation of a decoding method is important also for security aspect. In the technical standards, there are techniques available for supporting correct decoding, for example, range test and reasonableness test for CPR decoding in RTCA DO-260B. Although they are not originally intended for security purpose, reduction of false position information is expected.

The CPR reasonableness test is a technique to verify the decoded position. The basic mechanism of the reasonable test for locally unambiguous decoding is detecting a position jump from previous decoding. The criteria is available in DO-260B. The basic mechanism of the reasonable test for globally unambiguous decoding is decoding an additional pair of signal and use it for verifying the previous decoding.

The CPR reasonableness test is included in the ADS-B message decoding logic in DO-260B together with a range test, which checks whether the output of globally unambiguous decoding is within the receiver’s operational coverage. The range test and CPR reasonableness test are included also in EUROCAE ED-129B (Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground System).

Commissioning Readiness		
The requirement for this form is specified in the System Management Manual (Section 11.2 of V4), C-MAN0107		
Project/Task Name	SAP Project/Task ID:	Sites or Locations affected:
Documentation prepared by:	Date:	Commissioning Date:
Affected System(s)	System Criticality	Change Consequence Level
Brief Description of Change:		

Commissioning Readiness Endorsement		
The endorsement of this form by the appropriate authorities as specified in the System Management Manual certifies that the requirements detailed in this form (with the exception of the non-critical deficiencies ¹ listed herein) have been completed prior to the commissioning of the system change or new system.		
Chief Engineer or Technical or Maintenance Authority		
Name:	Signature:	Date:
Designation:		
Name:	Signature:	Date:
Designation:		
Chief Operating/User Authority or Operating/User Authority		
Name:	Signature:	Date:
Designation:		

Records Management Instructions
Place the completed Commissioning Readiness Form, together with any support documents on the Project file
Provide a copy of the completed Commissioning Readiness Form to P&E, Asset Lifecycle Manager, Planning and Integration

Note 1: Non-critical deficiencies (NCD) are those outstanding technical and operational issues that do not prevent the safe and effective use or maintenance of the facility, but will be addressed in a specified and agreed time. NCDs shall be listed on the Commissioning Certificate (C-FORMS0300) and recorded in the relevant system (ASID / HEAT / SAIR). It is preferable for each NCD to be recorded as a separate Issue.

SYSTEM MANAGEMENT MANUAL
CHANGE CONTROL
C-FORMS0348

Item No:	Requirement:	Requirement Reference: (Procedure/Instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
1	OPERATIONAL SAFETY			
1.1	Provide a link to the completed SCARD SCARD Template (AA-TEMP-SAF-0042) Note: For unregulated systems the SCARD shall be used to assess the impact of the change and perform a preliminary hazard analysis	Safety Change Management Requirements AA-NOS-SAF-0104	Completed ☐ N/A ☐	Link to SCARD
1.2	The outcome of the SCARD will be the requirement for one of the following for commissioning: Safety Statement – included in SCARD or standalone Safety Statement which must provide Airservices Australia management with sufficient information to demonstrate that safety has been considered and the change presents minimal or no safety issues. Safety Plan & Safety Assessment Report, or Safety Plan & Safety Case Safety Plans, Safety Assessment Reports and Safety Cases are required to be available in the Document Search Database	Safety Change Management Requirements AA-NOS-SAF-0104 Document Search Database	Completed ☐ N/A ☐	Link to Safety statement or Link to Safety Plan & Safety Assessment Report or Link to Safety Plan & Safety Case
1.3	Safety risk management process completed and includes - any new hazards / impact to existing hazards identified? - controls identified and in place? and - residual risk justified and accepted.	Safety Risk Management Procedures AA-PROC-SAF-0105	Completed ☐ N/A ☐	
1.4	Impacts on the Operational Risk Assessments from residual risks have been assessed and implemented using Operational Risk Assessment Change Request and Acceptance Record – AA-FORM-SAF-0032	Operational Risk Assessment AA-NOS-SAF-0006 Safety Risk Management Procedures AA-PROC-SAF-0105	Completed ☐ N/A ☐	Link to Operational Risk Assessment Change Request and Acceptance Record:
1.5	Arrangements for monitoring and review of risks are in place including arrangements for safety performance monitoring following the transition.	Safety Risk Management Procedures AA-PROC-SAF-0105	Completed ☐ N/A ☐	
1.6	CASA have approved / accepted or been advised of the change, as applicable	Safety Change Management Requirements AA-NOS-SAF-0104	Completed ☐ N/A ☐	

C-FORMS0348

Version 3: Effective 21 August 2012

Form approved by: Branch Manager, Operational Integrity & Compliance

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Commercial in Confidence

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Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
2 WORKPLACE HEALTH & SAFETY				
2.1	Initial WHS Hazard Identification must be completed as per the template AA-TEMP-SAF-0020	Safety Risk Management Procedures AA-PROC-SAF-0105 Initial WHS Hazard Identification AA-TEMP-SAF-0020 Workplace Health and Safety Risk Management Summary AA-TEMP-SAF-0016	Completed ☐ N/A ☐	Link to completed Workplace Health and Safety Management Summary AA-TEMP-SAF-0016
2.2	Ensure employees and stakeholders are consulted when significant changes to work arrangements are being considered.	Working Together Workplace Consultation AA-PROC-SAF-0009	Completed ☐ N/A ☐	
2.3	Tower Access / Classification assessed? Working at Heights Safety Checklist & Daily Toolbox Meeting (F098) Fall arrest facility / equipment available	Working at Heights PROC-157 Working at Heights Safety Checklist & Daily Toolbox Meeting F098	Completed ☐ N/A ☐	
2.4	WHS hazard controls are in place - Safe Work Method Statement completed - Plant risks managed - Radhaz survey completed, published on the Avnet and general public & occupational exposure boundaries identified	Safe Work Method Statement AA-TEMP-SAF-0017 Managing WHS Risk for Contractors and Projects AA-PROC-SAF-0012 Plant Risk Management PROC-134 RF Radiation, Surveys & Health & Safety Mgmt PROC-121	Completed ☐ N/A ☐	Link to completed Safe Work Method Statement AA-TEMP-SAF-0017 Link to completed F131 Plant Risk Management Checklist
2.5	At the completion of works ensure WHS Inspections are completed and hazard controls are in place. Building condition; clean, undamaged, all work completed.	Conducting Workplace Safety Inspections AA-PROC-SAF-0008	Completed ☐ N/A ☐	

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3 ENVIRONMENT				
3.1	Environmental Impact must be assessed using the Environmental Impact Screening & Assessment Criteria for Changes to On-ground Activities Assistance in assessing the Environmental Impact can be obtained from Environment and Climate Change Unit in Environment Group.	Environmental Screening & Assessment Criteria for Changes to On-ground Activities AA-REF-ENV-0010 Environmental Assessment of Changes to On-ground Activities AA-NOS-ENV-2.200	Completed ☐ N/A ☐	Link to completed Environmental Impact Screening and Assessment Form If a stage 2 assessment is required provide ARMS reference and links to any Permits, Master Development Plans and relevant correspondence as required.
3.2	Environmental Clearance obtained for ATM changes as per AA-NOS-ENV-2.100 Assistance in assessing the Environmental Impact can be obtained from Environment and Climate Change Unit in Environment Group.	Environment Assessment Process for ATM Changes AA-NOS-ENV-2.100	Completed ☐ N/A ☐	Provide ARMS reference and NRFC reference if ATM change required
4 PEOPLE- SUPPORT				
ATC TRAINING				
4.1	ATC Training Needs Analysis completed and Training Plan developed?		Completed ☐ N/A ☐	Link to Training Needs Analysis and Training Plan
4.2	Sufficient number of trained, rated and endorsed ATC staff available.		Completed ☐ N/A ☐	Number Trained:
4.3	ATC staff individual training records in SAP database have been updated		Completed ☐ N/A ☐	
4.4	Plans are in place to complete any outstanding training, rating, and endorsement of remaining ATC staff (Normally an identified hazard)		Completed ☐ N/A ☐	HAZLOG Register No:

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TECHNICAL TRAINING				
4.5	Training Needs Analysis completed and Training Plan developed for system support staff and field maintenance staff?		Completed ☐ N/A ☐	Link to Training Needs Analysis and Training Plan
4.6	TechCert codes have been created, assessment criteria developed or existing assessment criteria has been amended	TechCert codes TechCert Guides and Forms	Completed ☐ N/A ☐	Link to TechCert Guides and Forms
4.7	Sufficient system support staff and field maintenance staff appropriately trained?		Completed ☐ N/A ☐	
4.8	Are plans in place to complete any outstanding training and certification of system support staff and remaining field maintenance staff?		Completed ☐ N/A ☐	
4.9	Field maintenance staff hold the relevant TechCert to perform duties.	Technical Certification PROC-141	Completed ☐ N/A ☐	
4.10	Statutory / special licensing obtained by field maintenance staff including high risk work competencies and licensing requirements?		Completed ☐ N/A ☐	
4.11	ABS and FMS staff training details sent to Technical Training Coordinator and training records updated as required?	Training PROC-119	Completed ☐ N/A ☐	
4.12	TechCert details sent to FMS System Support to update the Qualifications (TechCert) Database	Technical Certification PROC-141	Completed ☐ N/A ☐	
LOGISTICAL SUPPORT				
4.13	CMRD have been consulted regarding special test equipment, test beds, etc		Completed ☐ N/A ☐	

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4.14	CMRD / NDC have been consulted regarding spares holdings and repair of LRUs from this equipment or in-house support of Depot Level Support Contract / repair contract		Completed ☐ N/A ☐	
4.15	TEMACC advised of any specialised test equipment requirements.	Test Equipment Management PROC-150	Completed ☐ N/A ☐	
4.16	Maintenance support contracts in place (external and/or internal)? — Appropriate vendor and/or internal support? — Appropriate Level 3 maintenance arrangements		Completed ☐ N/A ☐	
4.17	Test equipment provided to maintenance base. Note: Test equipment purchasing and calibration requirements detailed in Engineering Execution Readiness form.		Completed ☐ N/A ☐	
4.18	Specialised hardware or software system support and field maintenance tools, test / patch leads, adaptors, isolators, electronic discharge protection (mats, straps), etc supplied?		Completed ☐ N/A ☐	
4.19	System Business Continuity/ Disaster Recovery provisions supplied/updated?		Completed ☐ N/A ☐	
4.20	Spares – Supplied, storage correct, transport cases supplied?	Management of Goods & Supplies PROC-118	Completed ☐ N/A ☐	
4.21	Spares – Software / firmware loaded, tested & configured?		Completed ☐ N/A ☐	
4.22	Service Restoration Times (SRT) established?	Airways Service Data PROC-207	Completed ☐ N/A ☐	

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4.23	Conduct Hardware physical configuration audit and ensure SAP Plant Maintenance has updated information of all installed and/or demolished equipment (including monitoring circuits) and sent to System Operations SAP PM DATA CHANGES	Equipment Installed/Demolished Advice SAP Data Input Form F104	Completed ☐ N/A ☐	Link to Email from SAP PM Support confirming update/s
5 PROCEDURES				
ATC DOCUMENTATION				
5.1	System Requirements documentation including Operating Concept or Business Process Rules - produced/updated and approved?		Completed ☐ N/A ☐	Link to documentation
5.2	Manual of Air Traffic Services (MATS) reviewed / updated. Aeronautical information publications (AIP Book, AIP SUPP, AIC, DAP, ERSA, Charts, etc) reviewed / updated. Amendment times are determined by the AIS Distribution Schedule	AA Publications AIS Distribution Schedule	Completed ☐ N/A ☐	NRFC No.
5.3	National ATC Procedures Manual (NAPM) and any other relevant ATC procedures reviewed / updated.		Completed ☐ N/A ☐	NRFC No.
5.4	ATC contingency / continuity plans reviewed / updated.	ATS Contingency Plans Business Continuity Plans C-BCP	Completed ☐ N/A ☐	ATS-CP No: C-BCP No:
5.5	NOTAM and/or AIP SUP issued / amended / cancelled	Works Planning PROC-213 Refer also LOA3024	Completed ☐ N/A ☐	NOTAM No:
5.6	ATC Temporary Local Instruction (TLI) issued notifying Operational staff of change?	Temporary Local Instructions & Database	Completed ☐ N/A ☐	NRFC No.

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USER DOCUMENTATION				
5.7	User/operator manuals updated		Completed ☐ N/A ☐	
5.8	User/operator procedures provided/updated as applicable		Completed ☐ N/A ☐	
5.9	On-line user/operator documentation completed and published		Completed ☐ N/A ☐	
5.10	ARFF instructions updated		Completed ☐ N/A ☐	
5.11	Other Business Groups instructions updated?		Completed ☐ N/A ☐	
TECHNICAL DOCUMENTATION				
5.12	Software design documents updated, adequate and supplied to system support?		Completed ☐ N/A ☐	
5.13	Software and/or dataset Version or Release Description Documentation supplied and adequate?		Completed ☐ N/A ☐	Link to Version Description Document or Release Description Document
5.14	Software installation procedure and instructions supplied/updated and adequate?		Completed ☐ N/A ☐	Link to Installation Procedure

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5.15	SMP: System Management Plan created / updated and adequate?	SMP Template	Completed ☐ N/A ☐	SMP No:
5.16	SCP: System Contingency / continuity plans supplied/updated and adequate?	SCP Template	Completed ☐ N/A ☐	SCP No:
5.17	Technical drawings updated and listed in Data Viewer and list supplied to system supporters and field maintenance staff.	Technical Drawing Management PROC-178	Completed ☐ N/A ☐	
5.18	Technical handbooks/manuals supplied to ABS or FMS Engineering/IT support and field maintenance staff (base and site copy).	Document Management PROC-103	Completed ☐ N/A ☐	
5.19	On-line system support and field maintenance documentation completed and published		Completed ☐ N/A ☐	
5.20	Technical documentation registered and placed under documentation control	Document Management PROC-103	Completed ☐ N/A ☐	
5.21	Appropriate engineering performance requirements specified and issued for ongoing use? System Specification documentation supplied/updated and adequate?	System Performance Requirements & Reporting Specification ASYS-106	Completed ☐ N/A ☐	
5.22	Configuration & Modification AEI: Equipment and System Modifications and Configuration (for hardware and software), and Software Release Authorisations are documented in a Part 2 AEI (or other approved documentation)	Development of Maintenance Instructions for Equipment PROC-151	Completed ☐ N/A ☐	AEI No/s: Link to documentation detailing configuration and modification
5.23	Maintenance AEI: Maintenance requirements, including Performance Inspection tolerances, have been defined and documented in AEIs (or other approved documentation). (AEI Part 3.4.7)	Development of Maintenance Instructions for Equipment PROC-151	Completed ☐ N/A ☐	AEI No/s:

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5.24	AEI: New maintenance AEIs trialled by maintenance staff	Development of Maintenance Instructions for Equipment PROC-151	Completed ☐ N/A ☐	
5.25	TTD: Temporary Technical Dispensation raised and published on the Document Search database.	Temporary Technical Dispensations PROC-153	Completed ☐ N/A ☐	TTD No:
5.26	Site Manifest updated	Site Manifests FMS-304	Completed ☐ N/A ☐	
6	SYSTEM			
DESIGN REQUIREMENTS				
6.1	System Requirements documentation including Operating Concept or Business Process Rules - supplied/updated and approved?	Design Control PROC-146	Completed ☐ N/A ☐	Links to documentation
6.2	Standards – Installation and equipment comply with all relevant Australian Standards? Building Codes - Structures comply with the relevant Building Codes? The relevant Australian Standards and Building Codes are to be determined by the Chief Engineer, Technical Authority or Maintenance Authority	Australian Standards Design Control PROC-146	Completed ☐ N/A ☐	
6.3	Other applicable Federal and/or State licensing requirements met? The relevant licensing requirements are to be determined by the Chief Engineer, Technical Authority or Maintenance Authority	Design Control PROC-146	Completed ☐ N/A ☐	

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6.4	Electrical Mechanical, Structure and Building impacts have been assessed as adequate or modifications organised and completed through consultation with Engineering Branch, P&E? (Power supply capability / airconditioning capacity / mast loadings)	Design Control PROC-146	Completed ☐ N/A ☐	
6.5	Earthing and Lightning Protection meets Aircservices requirements?	Earthing and Lightning Protection Systems for Operational Facilities AEI 3.1504 Site Earthing and Lightning Protection Systems for Existing Installations AEI 2.3011	Completed ☐ N/A ☐	
6.6	Battery Procurement as per Aircservices requirements?	Lead Acid Batteries (Stationary) Procurement and Acceptance Testing AEI-3.7050 Panel Contract Arrangement C-PROC0140	Completed ☐ N/A ☐	
6.7	Assessing the impact of information systems against corporate objectives (7 Ticks process).	Information Technology Application Certification – 7 Ticks MI-0804 and PROC-190	Completed ☐ N/A ☐	Link to completed 7 Ticks Interim Certificate or Final Certificate
6.8	IT Security measures appropriate and in place (ie. to ensure effective security and control practices to minimise the risks of unauthorised access, inappropriate use, modification, destruction or disclosure of electronically held data).	IT Security Roles and Responsibilities Statement MS-0013 Information Security MI-0808 ICT Resources – Conditions of Use MI-0829	Completed ☐ N/A ☐	

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6.9	Information Security	Information Security C-PROC0184	Completed ☐ N/A ☐	Link to completed security risk management plan
INSTALLATION REQUIREMENTS				
6.10	Has met the regulation and safety requirements for Telecommunications Installations. Cable Markers installed (external)? Equipment complies with ACMA statutory requirement Telecommunication Labelling (Customer Equipment and Customer Cabling) Notice 2001 as amended (i.e. 'A' ticked on the equipment compliance plate)	Implementing Regulation and Safety Requirements for Telecommunications Installations PROC-138 Installation of Optical Fibre Cable - Underground AEI 4.5001 Underground Cable Marking AEI 4.3001	Completed ☐ N/A ☐	Link to Telecommunications Cabling Advice
6.11	MDF/IDF Records created / updated? Labelling/Colour Coding – Rack, Cable, Chassis, etc. ?	Colour Coding of RJ45 Patch Leads for Voice and Data Installations AEI 7.3241	Completed ☐ N/A ☐	
6.12	Transmitters licence label affixed	Radio Communication Transmitter Labelling AEI 7.4238	Completed ☐ N/A ☐	
6.13	Electrical Certificate of Testing and Safety or Testing and Compliance on connection to a source of electricity (i.e. installation conforms to AS3000) are required to be supplied as soon as possible after connection or testing of any electrical installation or change. Labelling – Switch Boards, etc Meets Airservices Electrical Cable Colour Coding requirements?	Electrical Safety Regulation 2002 Sections 15 and 159 AS 3000 – Aust Standard Electrical Cable Colour Coding AEI 3.1502	Completed ☐ N/A ☐	Links to Electrical Certificates

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6.14	All modifications complete and scratch plate labels affixed to equipments	Identification of Airways Systems Equipment Hardware Modifications PROC-154	Completed ☐ N/A ☐	
6.15	Integration with National Technical Monitoring has been organised and completed through Engineering Branch, P&E?		Completed ☐ N/A ☐	
6.16	Alarm monitoring installed and tested at TOC for local and remote site?		Completed ☐ N/A ☐	
6.17	Source media – supplied/backed up, stored, registered with system support?	Software Media Archival and Storage PROC-147	Completed ☐ N/A ☐	
6.18	Site installable media – supplied/backed up, appropriately stored and registered by field maintainers?	Software Media Archival and Storage PROC-147	Completed ☐ N/A ☐	
6.19	Software licences provided, registered and appropriately stored? (Including details of any third party licensing)		Completed ☐ N/A ☐	
6.20	Update HEAT and/or ASID database to incorporate new system/version number and assign issue management roles?		Completed ☐ N/A ☐	

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DESIGN CONFIRMATION				
6.21	Airservices Physical Security requirements met. The minimum security requirements are specified in C-GUIDE0157. Physical Security advise can be obtained from the relevant Security Advisor in Security and Crisis Planning, Safety & Environment Physical Access requirements are determined and established Siting and accommodation impact has been assessed as being satisfactory or modifications organised through National Property?	Physical Security – Critical Operational Facilities C-GUIDE0157 Site Management PROC-170	Completed ☐ N/A ☐	
6.22	Network data load impact has been assessed as being satisfactory or modifications organised and completed through Engineering Branch, P&E?		Completed ☐ N/A ☐	
6.23	Spectrum licences (either cancelled if no longer required or for new licenses including if antenna moves by more than 10 metres)	Frequency Management: Obtaining a Frequency Assignment and Licence AEI 7.4202	Completed ☐ N/A ☐	
6.24	New system or system change acceptance tests (software and/or hardware) satisfactorily completed against the approved system requirements? — Test Plans provided? — FAT, SAT, UAT test results complete, passed to the required level and provided? — Test identified defect listings and re-test information provided?	System Management Manual SMM Design Control PROC-146	Completed ☐ N/A ☐	
6.25	Battery Acceptance Tests as per Airservices requirements?	Lead Acid Batteries (Stationary) Procurement and Acceptance Testing AEI-3.7050	Completed ☐ N/A ☐	Link to Battery Acceptance Test Results

Item No:	Requirement:	Requirement Reference: (Procedure/Instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
6.26	Standard Operating Conditions (SOCs) / Site Configuration Data (SCD) established / approved	Standard Operating Conditions & Site Configuration Data Management PROC-143	Completed ☐ N/A ☐	
6.27	Flight Test results supplied and satisfactory	Certification of Radio Navigation Aid Facilities AEI 7.4003	Completed ☐ N/A ☐	
6.28	Equipment operation is as per AEI specifications and any additionally specified requirements? Relevant requirements and performance specifications to be determined by the Chief Engineer, Technical Authority or Maintenance Authority		Completed ☐ N/A ☐	
7 TRANSITION				
PLANNING				
7.1	Does the system meet all critical user and technical requirements?		Completed ☐ N/A ☐	
7.2	If non-critical deficiencies are proposed to be accepted into operation, are they managed and tracked via ASID, HEAT or SAIR, including responsibilities and timings and attached to the Commissioning Certificate?		Completed ☐ N/A ☐	
7.3	Cutover Plan prepared and authorised by: – Appropriate level of engineering authority? – Appropriate level of User Authority?	Cutover Plan C-TEMP0045	Completed ☐ N/A ☐	Link to Cutover Plan
7.4	Works plan created at least 7 days before deployment	Works Planning PROC-213	Completed ☐ N/A ☐	Works Plan No.

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NOTIFICATION				
7.5	Industry education / notification been completed?		Completed ☐ N/A ☐	
7.6	Relevant Business Managers advised of impending change?		Completed ☐ N/A ☐	
7.7	Change requester and/or sponsor notified?		Completed ☐ N/A ☐	
7.8	System Operations' TOC and Service Desk notified and accepted operating responsibility for the change.		Completed ☐ N/A ☐	
7.9	ABS/FMS Manager has accepted maintenance responsibility		Completed ☐ N/A ☐	
7.10	Notify the following (as appropriate) that the system is at "OPERATIONAL READINESS" and provide details of commissioning and any system changes: ATC System Supervisor, Melbourne (ATC) System Supervisor, Brisbane (ATC) National ATC Systems Manager Operating Authority (relevant)	Sys to Svc List	Completed ☐ N/A ☐	

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7.11	Notify the following (as appropriate) that the system is at “ENGINEERING READINESS” and provide details of commissioning and any system changes: P&E Technical Authority (relevant) Technical Operations Centre – Director Service Desk -Airways SAP PM Support	Sys to Svc List	☐ Completed ☐ N/A	

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COMMISSIONING CERTIFICATE

The requirement for this form is specified in the System Management Manual (Section 11.2 of V4), C-MAN0107

Project/Task Name	SAP Project/Task ID:	Sites or Locations affected:
Documentation prepared by:	Date:	Commissioning Date:
Affected System(s)	System Criticality	Change Consequence Level
Brief Description of Change:		

Commissioning Approval

The approval of this document by the appropriate authorities as specified in the System Management Manual certifies that the new system or system change is satisfactory to meet the specified service and performance requirements; that system operating and support requirements are in place; that required user and technical training is adequately provisioned; as detailed in the Commissioning Readiness Form and consequently the new system or system change is declared fit-for-purpose and can be deployed and operated until formally decommissioned or otherwise revoked.

This approval is provided subject to the non-critical deficiencies¹ listed herein.

Chief Engineer, Technical or Maintenance Authority

Name	Signature:	Date

Designation:

Name:	Signature:	Date:

Designation:

Chief Operating/User Authority or Operating/User Authority

Name:	Signature:	Date:

Designation:

Records Management Instructions

Place the completed Commissioning Certificate, together with the completed Commissioning Readiness form on the Project file

Provide a copy of the completed Commissioning Certificate, and the completed Commissioning Readiness Form to P&E, Asset Lifecycle Manager, Planning and Integration

Note 1: Non-critical deficiencies are those outstanding technical and operational issues that do not prevent the safe and effective use of the facility by users or prevent effective technical maintenance, but will be addressed in a specified and agreed time.

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LIST OF NON-CRITICAL DEFICIENCIES WAIVED AT TIME OF COMMISSIONING				
Either list non-critical deficiencies here or attach a list if space insufficient				
Issue	Issue Tracking Reference Number	Allocated to	Proposed Completion Date	Comments

Guidance Materials on Monitoring and Analysis of ADS-B Avionics Performance

1 Introduction

- 1.1 The APANPIRG has endorsed the following Conclusion during its 24th Meeting to encourage States/Administration to exchange their ADS-B performance monitoring results and experience gained from the process :

Conclusion 24/45 - Exchange ADS-B Performance Monitoring Result

“That, States be encouraged to exchange findings/result of their ADS-B performance monitoring including experience gained in conducting the required performance monitoring.”

- 1.2 Since the ADS-B mandate for some airspace in the Region became effective in December 2013, monitoring and analysis on avionics performance of ADS-B equipped aircraft has become an increasingly important task for concerned States. The fully functional ADS-B Avionics Problem Reporting Database (APRD) was launched on the 21 July 2017. The database is placed at ICAO APAC website in the restricted area with name: APAC ADS-B Avionics Problem Reporting Database accessible via <https://applications.icao.int/ADSB-APRD/login.aspx>. States are encouraged to make full use of the APRD for reporting ADS-B avionics problems and sharing experience as well as follow-up actions through the APRD web-page.
- 1.3 This document serves to provide guidance materials on monitoring and analysis of avionics performance of ADS-B equipped aircraft, which is based on the experience gained by States.

2 Problem Reporting and Feedback

- 2.1 For ADS-B avionics problems, it is critical that an appropriate reporting and feedback mechanism be established. It is highly desirable that those discovering the problems should report them to the appropriate parties to take action, such as study and analyse the problems, identify the root causes, and rectify them. Those action parties include :-
- (a) Air Navigation Service Providers (ANSPs) – upon detection of any unacceptable ADS-B reports from an aircraft, report the observed problem to the performance monitoring agent(s), if any, and the Aircraft Operators for investigation. In addition, ANSPs should take all actions to avoid using the ADS-B reports from the aircraft until the problem is rectified (e.g. black listing the aircraft), if usage of such reports could compromise safety.
 - (b) Regulators – to initiate any appropriate regulatory action or enforcement.

- (c) Aircraft Operators – to allow avionics specialists to examine the causes and as customers of the avionics manufacturers ensure that corrective action will take place.
- (d) Avionics Manufacturers and Aircraft Manufacturers – to provide technical evidence and knowledge about the problem and problem rectification

2.2 Incentives should be received by those parties acting on the problems including :-

- (a) Regulations that require deficiencies to be rectified
- (b) Regulatory enforcement
- (c) Consequences if conduct of operations with problematic equipment (e.g. no access to the airspace requiring healthy equipment)

2.3 When an ADS-B avionics problem is reported, it should come along with adequate details about the problem nature to the action parties. In addition, the problem should be properly categorised, so that appropriate parties could diagnose and rectify them systematically.

3 Problem Categorisation

3.1 Regarding ADS-B avionics, their problems are quite diversified in the Region but can be categorized to ensure they will be examined and tackled systematically.

3.2 Based on the experience gained from States, the common ADS-B avionics problems in the Region are summarized under different categories in Attachment A. It is noted that only a relatively minor portion of the aircraft population exhibits these problems. It must be emphasized that aircraft transmitting incorrect positional data with NUC = 0 or NIC = 0 should not be considered a safety problem. The data transmitted have no integrity and shall not be used by ATC. This situation exists for many aircraft when their GNSS receivers are not connected to the transponders.

4 Managing the Problem

4.1 There are two major approaches to manage the problems :-

(a) Regulatory approach

Regulations which require non-approved avionics to disable ADS-B transmission (or transmit “no integrity”), and the concerned operators to file flight plans to indicate no ADS-B equipage. APANPIRG has endorsed this approach which is reflected in the Regional Supplementary Procedures (Doc 7030).

(b) Blacklist approach

Filtering out (“black listing”) any airframes that do not comply with the regulations or transmitting bad data, and advising the regulator of the non-compliance. This approach is temporary which allows the ANSP to protect the system whilst regulatory action is underway.

While deciding on whether an aircraft transmitting erroneous ADS-B data should be added into the blacklist, the following factors will be critically assessed:

- i. Impact and risk to ATC operational safety
Use of erroneous ADS-B data to maintain separation may potentially contribute to loss of separation or ATC coordination error.
- ii. Frequency of erroneous position
Whether it is occasional or frequently broadcast of erroneous position.
- iii. Amount of deviation
This can be a track jumping problem which is of significant safety impact to ATC or just an occasional small position jump which is not detectable in ATC with insignificant impact.
- iv. Others
Such as the ICAO aircraft address received from ADS-B being inconsistent with the aircraft registration, Flight ID entered via cockpit interface mismatched with aircraft callsign in the Flight Plan, etc.

After deciding to put an aircraft into the blacklist list, the following procedures will be carried out:

- i. Informing the concerned aircraft operator/regulatory authority
The concerned aircraft operator/regulatory authority will be notified of the decision and the rationale before putting the aircraft into the exclusion list.
- ii. Pre-processing of flight plan concerned
As the blacklist mechanism involves filtering out the ADS-B data of the subject aircraft, from operational perspective, air traffic controllers need to be aware in advance that the concerned aircraft plans to operate in their FIR. A flight plan pre-processing system may locate the flight plan by checking against the 24-bit address or aircraft registration in the blacklist, and issue an alert to the air traffic controllers if appropriate, such as automatically insert a remark in the Item 18 of the concerned flight plan before feeding the flight plan into the ATC Automation System, and the ATC Automation System may issue an alert to the air traffic controllers with a specific label annotated in the corresponding electronic flight strips.
- iii. Coordinate with adjacent Area Control Centre (ACC)
Upon posting of pending inbound flights with corresponding electronic flight strips indicating non-ADS-B equipage or in the blacklist, the air traffic controllers shall inform the upstream ACC that transfer of that particular flight will not be accepted at the ADS-B exclusive airspace. It is important to carry out this coordination action as early as possible as the upstream sector may have difficulty to adjust the flight route at the transfer stage.
- iv. Handling of an aircraft for removal from the blacklist once rectification action had taken place
Once notification from the aircraft operators/regulatory authorities is received that the problem has been rectified, performance of the aircraft will be closely

monitored when it flies to the concerned FIR. If the aircraft shows the observed problem has been resolved, the aircraft will be removed from the blacklist. The aircraft operator/regulatory authority will also be notified accordingly.

5 Systematic Monitoring and Analysis of the Problem

States using ADS-B should have in place systematic ways to identify and manage ADS-B deficiencies similar to that described below :-

5.1 Reporting Deficiencies

States using ADS-B should have in place systematic ways to identify ADS-B deficiencies including :-

- (a) Systematic capture of ATC reported events and engineering detected events into a database; and
- (b) Manual or automatic detection of anomalous avionics behavior independent from controller reports

5.1.1 ATC Reported Deficiencies

ATC procedures should exist that allow services to continue to be provided safely, as well as to capture relevant information for later analysis. This should include :-

- (a) ATC request for the pilot to select the alternate transponder; and
- (b) ATC to adequately record the circumstances including Flight ID, ICAO Aircraft Address (if readily available) accurate time, Flight plan, and pilot provided information.

5.1.2 Non ATC reported deficiencies

5.1.2.1 Where capability is available, States should also identify non ATC reported deficiencies.

5.1.2.2 Without overlapping radar coverage: ADS-B data may be examined for the following :-

- (a) NUCp of each ADS-B reported position is smaller than required for service delivery for more than 5% of total number of ADS-B updates;
- (b) NIC, NACp, SIL are smaller than required for service delivery for more than 5% of total number of ADS-B updates;
- (c) ICAO Aircraft Address (i.e. I021/080) is inconsistent with the flight planned registration (REG) based on each state's ICAO Aircraft Address allocation methodology;

- (d) Flight ID entered via cockpit interface and downlinked in ADS-B data (i.e. I021/170 in Asterix CAT 21) is a mismatch¹ with aircraft callsign in the ATS Flight Plan;
- (e) Inconsistent vertical rate compared to flight level change; and
- (f) Inconsistency of position reports and presence of "jumps".

5.1.2.3 Overlapping radar coverage: For States that have overlapping radar coverage, a systematic means to monitor and analyze ADS-B could be considered in addition to relying on ATC to report the problem, or utilising the evaluation criteria in 5.1.2.2 above.

This can be achieved by comparing radar information with ADS-B reported position, velocity, flight level and vertical rate change data as well as examining the ADS-B quality indicators and Flight Identification (FLTID) contained in the ADS-B reports.

For each ADS-B flight, its ADS-B data could be compared with its corresponding radar information. For example, this would allow analysis to determine if the following pre-defined criteria are met :-

- (a) Deviation between ADS-B reported position and independent referenced radar position is greater than 1NM², with the indication of good positional quality in the quality indicators for more than 5% of total number ADS-B updates. A sample screen shot of a system performing the analysis automatically is given at Attachment B for reference.

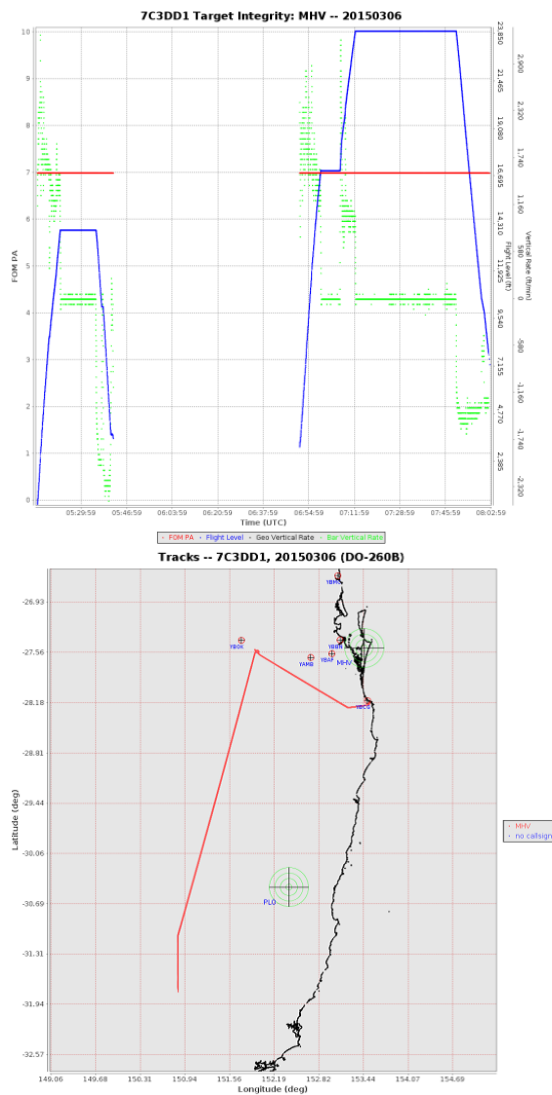
5.2 Managing and Processing Deficiencies

Whether detected by ATC or not, all deficiencies should trigger:

- (a) Systematic recording of the details of each occurrence such as date/time of occurrence, ICAO aircraft address and flight plan information should be obtained. Graphical representations such as screen capture of radar and ADS-B history tracks, graphs of NUCp/NIC value changes versus time and deviation between radar and ADS-B tracks along the flight journey would be desirable. Examples of typical graphical representations are shown below :-

¹ A missing Flight ID, or a Flight ID with only "spaces" should not be considered a mismatch.

² For example, the deviation between ADS-B and radar tracks could be set to 1NM in accordance with ICAO Circular 326 defining position integrity ($0.5\text{NM} < \text{HPL} < 1\text{NM}$) for 3NM aircraft separation use, on assumption that radar targets are close to actual aircraft position. The values of ADS-B quality indicators (NUCp, NACp, SIL, NIC) could be chosen based on the definition in ICAO Circular 326 on Position Accuracy and Position Integrity for 3NM aircraft separation minimum. A threshold of 5% is initially set to exclude aircraft only exhibiting occasional problems during their flight journey. The above criteria should be made configurable to allow fine-tuning in future. Evaluation of ADS-B vs radar may alternatively expose radar calibration issues requiring further investigation.



- (b) Systematic technical analysis of each detected issue using ADS-B recorded data, to ensure that all detected issues are examined and addressed. Typically this will need:
- systems to record ADS-B data, replay ADS-B data and analyze ADS-B data
 - staff and procedures to analyze each report
 - A database system to manage the status of each event and to store the results of each analysis
- (c) Procedures to support engagement with operators (domestic & foreign), regulators, other ANSPs, Airframe OEMs and avionics vendors to ensure that each issue is investigated adequately and maximize the probability that the root cause of the event is determined. The procedures could include :-
- Data collection procedures;
 - Telephone & email contact details; and
 - Mechanisms for reporting, as appropriate, to the Asia Pacific ADS-B Avionics Problem Reporting Database (APRD)

* * * * *

Attachment A – List of known ADS-B avionics problems

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
1.	Track Jumping problem with Rockwell Collins TPR901 (See Figure1)	Software issue with TPR901 transponder initially only affecting Boeing aircraft. Does not occur in all aircraft with this transponder. Subsequent investigation by Rockwell Collins has found that the particular transponder, common to all of the aircraft where the position jumps had been observed, had an issue when crossing ± 180 degrees longitude. On some crossings (10% probability), errors are introduced into the position longitude before encoding. These errors are not self-correcting and can only be removed by a power reset of the transponder. The problem, once triggered can last days, since many transponders are not routinely powered down.	Yes. Will present as a few wild/large positional jumps. Nearly all reports are tagged as low quality (NUC=0) and are discarded, however, some occasional non zero reports get through. Problem is very “obvious”. Could result in incorrect longitudinal position of Flight Data Record track. Can trigger RAM alerts.	Rockwell Collins has successfully introduced a Service Bulletin that solves the problem in Boeing aircraft. The problem is known to exist on Airbus aircraft. Rockwell has advised that a solution is available in their DO260B upgrade. Rockwell Collins may not have a fix for some time. Workaround solutions are being examined by Airbus, Operators and Airservices Australia. The only workaround identified at this time is to power down the transponders before flight to states using ADS-B – after crossing longitude 180. It can be noted that in Airbus aircraft it is not possible to safely power down the transponder in flight. Airbus have prepared a procedure to support power down before flight. Airservices Australia have negotiated with 2 airlines to enact this procedure prior to flights to Australia. An additional partial workaround is :

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				to ensure that procedures exist for ATC to ask the pilot to changeover transponders if the problem is observed. Since there is a 10% chance of the problem occurring on each crossing of ± 180 degrees longitude, the chance that both transponders being affected is 1%. There is no complete workaround available for flights that operate across 180 degrees longitude directly to destination without replacing the transponder. Airbus advised that a new TPR901 transponder compliant with DO260B is available from December 2015. This new transponder does not have such problem.
2.	Rockwell Collins TDR94 Old version. The pattern of erroneous positional data is very distinctive of the problem. (See Figure 2)	Old software typically before version -108. The design was completed before the ADS-B standards were established and the message definitions are different to the current DO260. Rockwell has recommended that ADS-B be disabled on these models.	Yes. Will present as a few wild positional jumps. Nearly all reports are tagged as low quality (NUC=0) and are discarded, however, some occasional non zero reports get through. Also causes incorrect altitude reports. Problem is very “obvious”.	Problem well known. Particularly affects Gulfstream aircraft which unfortunately leave the factory with ADS-B enabled from this transponder model. Rockwell has issued a service bulletin recommending that ADS-B be disabled for aircraft with this transponder software. See Service Information Letter 1-05 July 19, 2005. It is easy to disable the transmission.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
3.	Litton GPS with proper RAIM processing	Litton GNSSU (GPS) Mark 1 design problem. (Does not apply to Litton Mark II). GPS does not output correct messages to transponder.	No. Perceived GPS integrity changes seemingly randomly. With the GPS satellite constellation working properly, the position data is good. However the reported integrity is inconsistent and hence the data is sometimes/often discarded by the ATC system. The effected is perceived extremely poor “coverage”. The data is not properly “protected” against erroneous satellite ranging signals – although this cannot be “seen” by ATC unless there is a rare satellite problem.	This GPS is installed in some older, typically Airbus, fleets. Data appears “Correct” but integrity value can vary. Performance under “bad” satellite conditions is a problem. Correction involves replacing the GNSSU (GPS) which is expensive. If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
4.	SIL programming error for DO260A avionics	Installers of ADS-B avionics using the newer DO260A standard mis program “SIL”. a) This problem appears for DO260A transponders, with SIL incorrectly set to 0 or 1 (instead of 2 or 3) b) As the aircraft enters	No. First report of detection appears good (and is good), all subsequent reports not displayed because the data quality is perceived as “bad” by the ATC system. Operational effect is effectively no ADS-B data. Hence no risk.	Would NOT be included in a “black list”. Aircraft with “Dyonon avionics” exhibit this behavior. They do not have a certified GPS and hence always set SIL = 0. This is actually correct but hence they do not get treated as ADS-B equipped.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		coverage, the ADS-B ground station correctly assumes DO260 until it receives the version number. c) The transmitted NIC (DO260A) is interpreted as a good NUC (DO260) value, because no SIL message has yet been received. The data is presented to ATC.		
5.	Garmin “N” Flight ID problem (See Figure 3)	Installers of Garmin transponder incorrectly set “Callsign”/Flight ID. This is caused by poor human factors and design that assumes that GA aircraft are US registered.	Yes. Flight ID appears as “N”. Inhibits proper coupling.	Can be corrected by installer manipulation of front panel. Does not warrant “black list” activity.
6.	Flight ID corruption issue 1 – trailing “U” Flight ID’s received : GT615, T615U ,NEB033, NEB033U, QF7550, QF7550U, QF7583, QF7583U, QF7585, QF7585, QF7585U, QF7594, QFA7521, QFA7531, QFA7531, QFA7531U, QFA7532, QFA7532U, QFA7532W, QFA7550, QFA7552,	TPR901 software problem interfacing with Flight ID source. Results in constantly changing Flight ID with some reports having an extra “U” character.	Yes. Flight ID changes during flight inhibits proper coupling or causes decoupling.	Affects mainly B747 aircraft. Boeing SB is available for Rockwell transponders and B744 aircraft. Rockwell Collins have SB 503 which upgrades faulty -003 transponder to -005 standard. If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	QFA7581			
7.	Flight ID corruption issue 2	ACSS software problem results in constantly changing Flight ID. Applies to ACSS XS950 transponder Pn 7517800-110006 and Honeywell FMC (pn 4052508 952). ACSS fix was available in Sept 2007.	Yes. Flight ID changes during flight inhibits proper coupling or causes decoupling.	Software upgrade available. If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
8.	No Flight ID transmitted	Various causes	No. Flight ID not available. Inhibits proper coupling.	Aircraft could “fail to couple with Flight Data Record”. Not strictly misleading – but could cause controller distraction.
9.	ACSS Transponder 10005/6 without Mod A reports NUC based on HFOM.		Yes. Appears good in all respects until there is a satellite constellation problem (not normally detectable by ground systems).	Not approved and hence not compliant with CASA regulations. If known could be added to black list. Configuration is not permitted by regulation.
10.	Occasional small position jump backwards (See Figure 4)	For some older Airbus aircraft, an occasional report may exhibit a small “jump back” of less than 0.1 nm Root cause not known	No. Not detectable in ATC due to extrapolation, use of latest data and screen ranges used.	ATC ground system processing can eliminate these.
11.	Older ACSS transponders report integrity too conservatively	Design error reports integrity one value worse than reality	No. In poor GPS geometry cases the	Can be treated in the same manner as a loss of transponder capability.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
			ATC system could discard the data when the data is in fact useable. Will be perceived as loss of ADS-B data.	
12.	Intermittent wiring GPS transponder	ADS-B transmissions switch intermittently between INS position and GPS position.	Yes. Normally the integrity data goes to zero when INS is broadcast, but sometimes during transition between INS and GPS, an INS position or two can be broadcast with “good” NUC value. Disturbing small positional jump.	If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
13.	Wrong ICAO Aircraft Address	Installation error	No. No direct ATC impact unless a rare duplicate is detected.	This is not a direct ADS-B problem, but relates to a Mode S transponder issue that can put TCAS at risk. Cannot be fixed by black list entry. Needs to be passed to regulator for resolution.
14.	Toggling between high and low NUC (See Figure 5)	Faulty GPS receiver/ADS-B transponder	No. ATC will see tracks appear and disappear discretely. No safety implications to ATC.	While it is normal for NUC value to switch between a high and low figure based on the geometry of GPS satellites available, it is of the view that more should be done to examine this phenomenon. It is observed that such switching between high and low NUC occurs on certain airframe and

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				not on others. The issue was raised to the airlines so as to get a better understanding. On one occasion, the airline replied that a module on their GPS receiver was faulty. On another occasion, the airline replied that one of the ADS-B transponder was faulty. Good NUC was transmitted when the working transponder was in use and poor NUC was transmitted when the faulty ADS-B transponder was in use.
15.	Consistent Low NUC (See Figure 6)	GNSS receivers are not connected to the ADS-B transponders.	No. Data shall be filtered out by the system and not detectable in ATC	Not considered a safety problem but a common phenomenon in the Region – the concerned aircraft will be treated equivalent to “aircraft not equipped with ADS-B”. While it is normal for aircraft to transmit low NUC, it is of the view that “consistent low NUC” could be due to the avionics problem (e.g. GNSS receiver is not connected to the ADS-B transponder). It is recognised that operators may not be aware that their aircraft are transmitting unexpected low NUC / NIC values, due to equipment malfunction. Hence, it is desirable for States to inform the operators when unexpected low NUC

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				values are transmitted, where practicable. Concerned airline operators are required to take early remedial actions. Otherwise, their aircraft will be treated as if non-ADS-B equipped which will be requested to fly outside the ADS-B airspace after the ADS-B mandate becomes effective.
16.	ADS-B position report with good integrity (i.e. NUC $\geq$ “4”) but ADS-B position data are actually bad as compared with radar (met criteria 5.2(a))	Faulty ADS-B avionics	Yes. As the ground system could not "automatically" discard ADS-B data with good integrity (i.e. NUC value $\geq$4), there could be safety implications to ATC.	The problem should be immediately reported to the concerned CAA/operators for problem diagnosis including digging out the root causes, avionics/GPS types etc., and ensure problem rectification before the ADS-B data could be used by ATC. Consider to “blacklist” the aircraft before the problem is rectified.
17.	FLTID transmitted by ADS-B aircraft does not match with callsign in flight plan (see Figures 7a – 7d)	Human errors	Yes. Could lead to screen clutter - two target labels with different IDs (one for radar and another for ADS-B) being displayed, causing potential confusion and safety implications to ATC.	Issue regulations/letters to concerned operators urging them to set FLTID exactly match with callsign in flight plan.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
18	B787 position error with good NIC	<u>Issue 1:</u> Software issue - surveillance system inappropriately “coasts” the position when data received by the transponder is split across multiple messages. System seems to self correct after some time. Can be corrected by surveillance system power off. <u>Issue 2:</u> Data packets were not being distributed to the transponder when the internal timing between different elements of the Integrated Surveillance System became synchronized.	Yes. Misleading position presentation which is typically detected by ATC observing aircraft “off track” when in fact it is “on-track”.	Boeing performed a change to the B787 Type Certificate for incorporation of the upgraded ISS software in March of 2017. All B787 aircraft delivered after Line number 541 have the upgraded ISS software which corrects this issue. Boeing released Service Bulletin B787-81205-SB340036-00 on 30 June 2017. Note that this Service Bulletin is available at no cost to the operator, and includes the concurrent requirement to implement Boeing Service Bulletin B787-81205-SB340005-00. On 5 Nov 2018, FAA issued Airworthiness Directive 2017-NM-118-AD, effective 10 Dec 2018, which requires application of Boeing SB B787-81205-SB340036-00 by 10 Dec 2019. EASA has invoked this AD for States under its jurisdiction. States and Operators are urged to implement the service bulletin immediately and report to FAA or ICAO APAC Office. As of 9 Sep 2020, 32 B787 aircraft were on the NSAL; 18 of these aircraft have been detected within

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				U.S. ADS-B coverage during 2020. The FAA is coordinating with State Regulators who have operators with B787 aircraft on the NSAL.
19	A number of airlines have reported or experienced ADS-B outages for complete flight sectors in A330 aircraft. Appears as low reliability ADS-B and has afflicted both A & B side at same time.	Being actively investigated. One airline has implemented on-board recording which confirms that the MMRs are not providing HIL/HPL to the transponder whilst continuing to provide HFOM, GPS alt etc	No. Equivalent to a failed transponder.	Aircraft must be managed procedurally if outside radar coverage.
20	A380 flight ID lost after landing	For the A380 fleet, it has been confirmed that for some seconds after landing, the flight ID is set as invalid by FMS to AECS. Consequently, the current AECS design uses, as per design, the Aircraft Registration Number as a back-up source for A/C flight identification field in ADS-B broadcast messages.	No.	The correction to this logic is planned for next AECS standard release; planned for 2017.” Only a problem for arriving aircraft on surface surveillance systems.
21	A350 ADS-B On-ground Performance	On departure, A350 aircraft will initially use INS derived position for ADS-B reports when taxiing and only use GNSS when entering the runway. INS positions can drift leading to inaccurate	Yes. where ADS-B is used for surface movement display	Airbus is in discussion with FAA and EUROCONTROL about this issue.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		position reports.		
22	Incorrect Ground Bit Setting (GBS) in both Mode S Interrogation Reply and ADS-B Downlink	Occasionally, some airborne aircraft will incorrectly set ground bit as “1” meaning they are on ground, while some landed aircraft incorrectly set ground bit as “0” meaning they are airborne. This could confuse the ATC system, by not showing the airborne targets as the system thought they are on ground, or forming tracks for landed targets triggering alarms against other taking-off aircraft.	Yes. Misleading information shown on ATC system. Aircraft not visible to TCAS and will not reply to all-call interrogations.	States/Administrations contact the concerned airline operators for remedial actions.
23	Rockwell TSS-4100 track extrapolation issue.	The TSS-4100 shares software with the Rockwell Collins ISS transponder in the B787, and the software defect in the B787 ISS reported at SURICG/2 also exists in the TSS-4100.	Yes. Misleading position presentation which is typically shown on ATC system.	FAA Airworthiness Directive (AD) 2017-22-14 was issued on 20 Dec 2017. The compliance date for this AD is 20 Dec 2018 (or 750 hours in service, whichever occurs first). FAA has not detected any aircraft with this issue since the AD compliance date and will not further report on it, as it is considered resolved.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
24	Embraer 170 track jumping issue	Unknown as being a random, occasional issue with no clear fault diagnosis available from Honeywell. FAA has decided that when the next E170 aircraft is detected with this issue, it will be immediately placed on the FAA's No Services Aircraft List (NSAL). Simultaneously, FAA will notify Embraer and Honeywell of the affected aircraft and request that appropriate engineering personnel be sent to inspect and test the affected aircraft.	Yes. Misleading position presentation which is typically shown on ATC system.	In all of the cases of this issue to date, removing and replacing the transponders cleared whatever the issue was. This issue has never recurred on the same aircraft. Bench testing by Honeywell avionics engineering of the removed transponders has revealed no faults or anomalies. As such, States/Administrations to consider removing and replacing the transponders concerned if issue observed. The FAA has since learned from discussions with the OEM that most recent events detected by FAA generated an "ADS-B NOT AVAIL" Crew Alerting System (CAS) message. When flight crews report this message, airline maintenance replaces the transponder(s), which resolves the problem. To date, this has consistently occurred before FAA monitoring detected the problem and engaged with the airline. The root cause for this issue remains unknown.
25	Airbus Single Aisle production wiring issue	FAA has observed 17 Airbus Single Aisle aircraft from two airlines with missing Length-Width Codes (LWC	No.	Airbus released three Service Bulletins to correct this issue, which existed in 128 Airbus Single Aisle aircraft.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		is a message element in DO-260B/ED-102A that is required by both the US and European mandates). FAA believes that this was a production line wiring issue.		As of 1-Dec-2018, all of the aircraft which operate at US airports with ADS-B surface surveillance were corrected. The FAA will not further report on this issue.
26	Boeing 777-300ER production wiring issue	FAA has observed at least 10 Boeing B777-300ER aircraft with missing or improper NACv/SDA/eCat/LWC message elements (these are message elements in DO-260B/ED-102A that are required by both the US and European mandates (eCat is FAA shorthand for Emitter Category). After notification, Boeing reported to FAA that this was a production line parity pin wiring issue.	No.	On 7 July 2017, Boeing released Service Bulletin SB 777-34-0281 to correct this issue. Boeing has informed FAA that all affected B777 operators have been notified. The FAA will not further report on this issue.
27	Rockwell TSS-4100 Geometric Altitude Reporting as Pressure Altitude	This issue exists in any TSS-4100 installed with TSSA-4100 software RCPN 810-0052-100, RCPN 810-0052-101, or RCPN 810-0052-102. All of the following must be true for the issue to occur: (1) TSS is the selected transponder; (2) TSS is receiving valid	Yes.	At present, the FAA regulator has determined that this issue occurs too rarely to warrant issuing an Airworthiness Directive or a Special Airworthiness Information Bulletin (SAIB). Rockwell Collins has released updated software, RCPN 810-0052-110, to address this issue. Refer to SIL TSSA-4100-10-1 titled, "TSSA-

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		pressure altitude; (3) TSS is receiving valid GPS data with an integrity of NIC 9 or better; and (4) The mode of operation for the transponder must be "ALT OFF". Note that in an SBAS service area, only condition (4) would be considered uncommon. When the issue exists, the TSS will insert geometric altitude information into the ADS-B Airborne Position Squitter, but this altitude will be encoded as if it were pressure altitude. The net effect is that, when this issue occurs, the TSS-4100 reports geometric altitude information as if it were pressure altitude. In many cases, this will be incorrect altitude information.		4100 Field Loadable Software", RCPN 523-0818785.
28	NACv reporting greater than 2	The FAA has detected a number of aircraft which	No.	While there is no known urgent issue with these findings, as no known

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		consistently report NACv = 3 and NACv = 4. Per FAA AC 20-165B section 3.3.3.7.3, “A NACv = 3 or NACv = 4 should not be set based on GNSS velocity accuracy unless you can demonstrate to the FAA that the velocity accuracy actually meets the requirement.” EASA CS-ACNS states that “There is currently no established guidance on establishing a NACv performance of ‘three’ or better.” Therefore, it appears that there are improperly configured ADS-B installations operating in the U.S.		ATC or airborne application requires NACv values exceeding two, FAA does have long-term intentions of deploying surveillance tracking and alerting prediction algorithms in ATC automation which will use real-time NACv values. ICAO States planning to make similar improvements should be aware of this situation.
29	B787 NACv = 0 Issue	FAA noted certain B787s exhibiting a relatively high percentage of NACv =0 reports. Starting with line number 442 (June 2016), Honeywell Integrated Navigation Receiver (INR) P/N 940-2001-008 was introduced,	No.	The erroneous NACv=0 condition clears at the next power up of the ISSPU. Boeing has issued guidance urging B787 operators to not intermix INR P/N 940-2001-002 or -004 (which do not output HFOMv) with INR P/N 940-2001-008 (which does output HFOMv) until the ISSPU software

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		which has an HFOMv output. Boeing investigations revealed a software flaw in the ISSPU that causes an erroneous NACv=0 reporting condition on B787s equipped with a mixed set of Honeywell INR part numbers. This condition occurs when the ISSPU switches between an INR with an HFOMv output and an INR without an HFOMv output.		has been updated per an available Boeing Service Bulletin. This guidance was provided in Boeing Fleet Team Digest 787-FTD-34-19005 (dated 21 Dec 2019). As of 9-Aug-2020, FAA has observed no significant occurrences of this issue within U.S. ADS-B coverage during the prior two months.
30	Honeywell Primus II RCZ issue	FAA observed that a number of operators equipped with the Honeywell Primus II integrated system were filing flight plans as ADS-B equipped, but not transmitting ADS-B. Honeywell had identified an issue where the ADS-B Out capable RCZ transponder and Radio Management Unit (RMU) components of the Primus II system will not broadcast ADS-B data if powered on under specific conditions. Also, the Radio Management Unit (RMU)	No	In October 2015, Honeywell released a Service Information Letter (Publication Number D201507000061) to notify customers of these power up conditions, the effect it would have on the Primus II equipment, and a potential work around to address the problem. In December 2019, Honeywell released Service Bulletin (SB) (Publication Number A21-2254-148) providing required modifications for the RMU to correct the ON/OFF logic for the ADS-B Out functionality. The FAA has been working in

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		will fail to notify the flight crew that ADS-B Out functionality is disabled.		collaboration with Honeywell to update the existing Service Information Letter to emphasize the importance of updating the RMU with the latest SB, to include implementing the option of configuring the ADS-B Out installation through a strap setting to provide indication of the ON/OFF control of ADS-B to the flight crew. The latest revision of the Service Information Letter will be referenced as part of the FAA issued Special Airworthiness Information Bulletin (SAIB) expected to be released before the end of December 2021.



Figure 1 - Track Jumping problem with TPR901



Figure 3 - Garmin “N” Flight ID problem

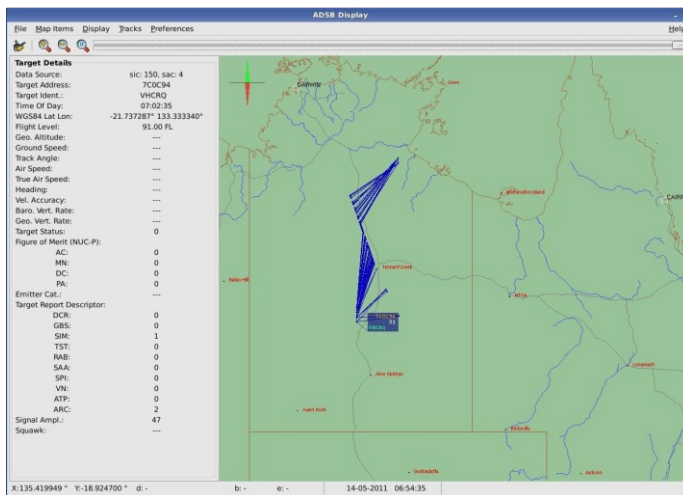


Figure 2 - Rockwell Collins TDR94 Old version. The pattern of

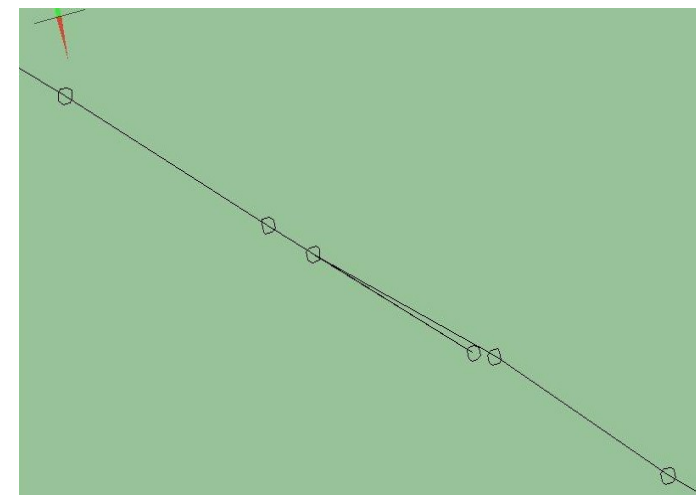


Figure 4 - Occasional small position jump backwards

erroneous positional data is very distinctive of the problem

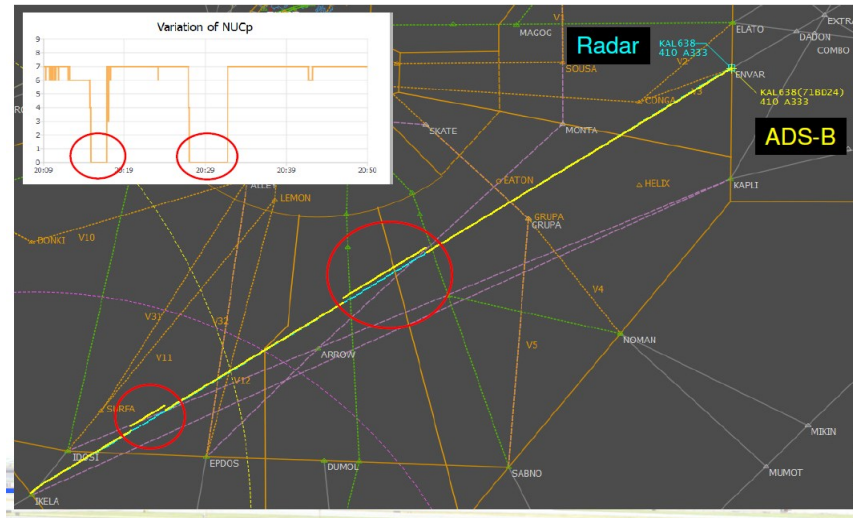


Figure 5 - NUC value toggling

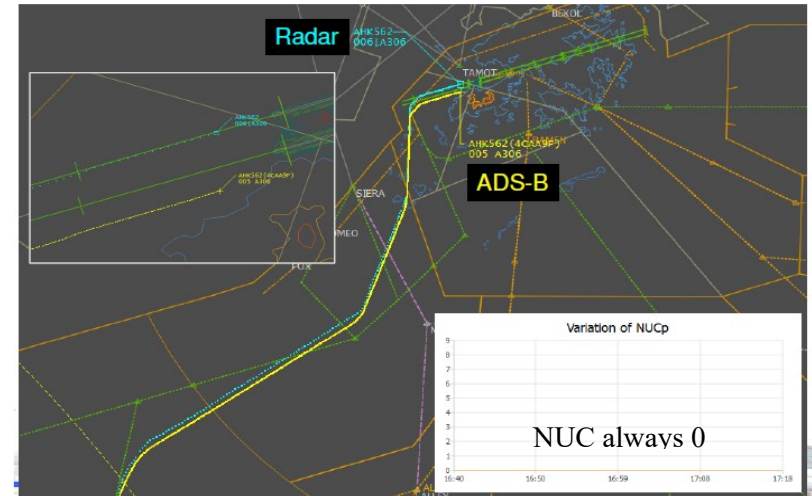


Figure 6 – Consistent low NUC

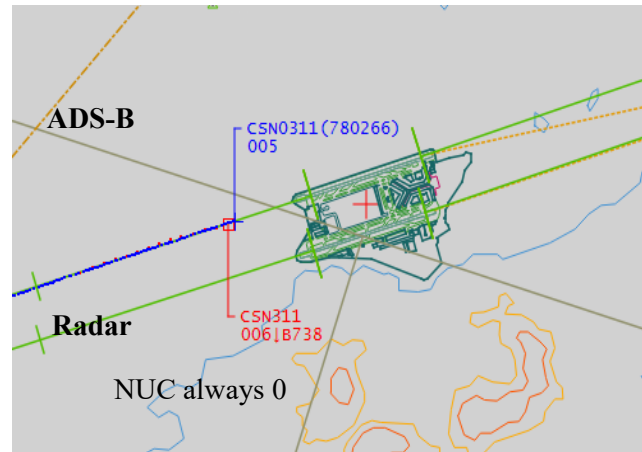


Figure 7a - Additional zero inserted

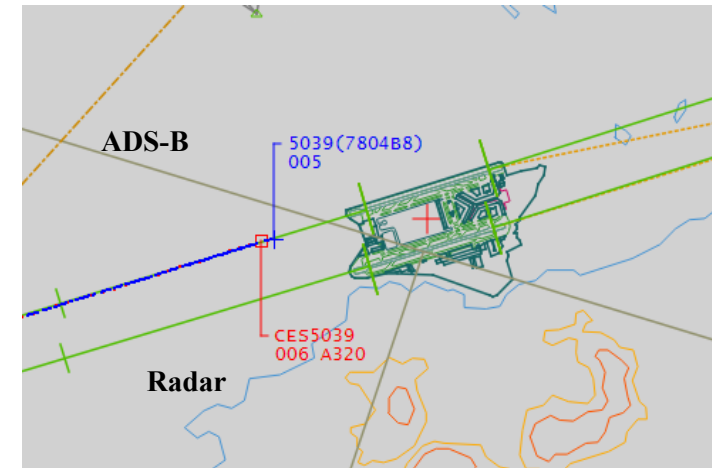


Figure 7b - ICAO Airline Designator Code dropped

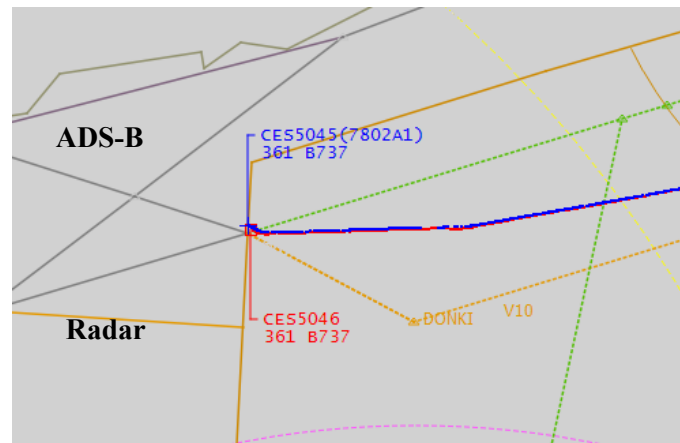


Figure 7c - Wrong numerical codes entered

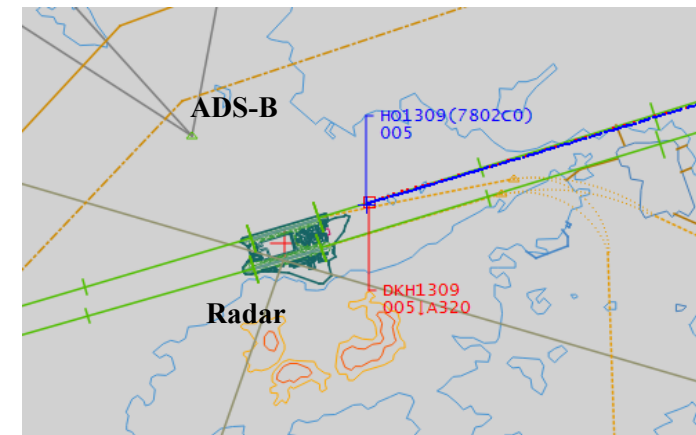
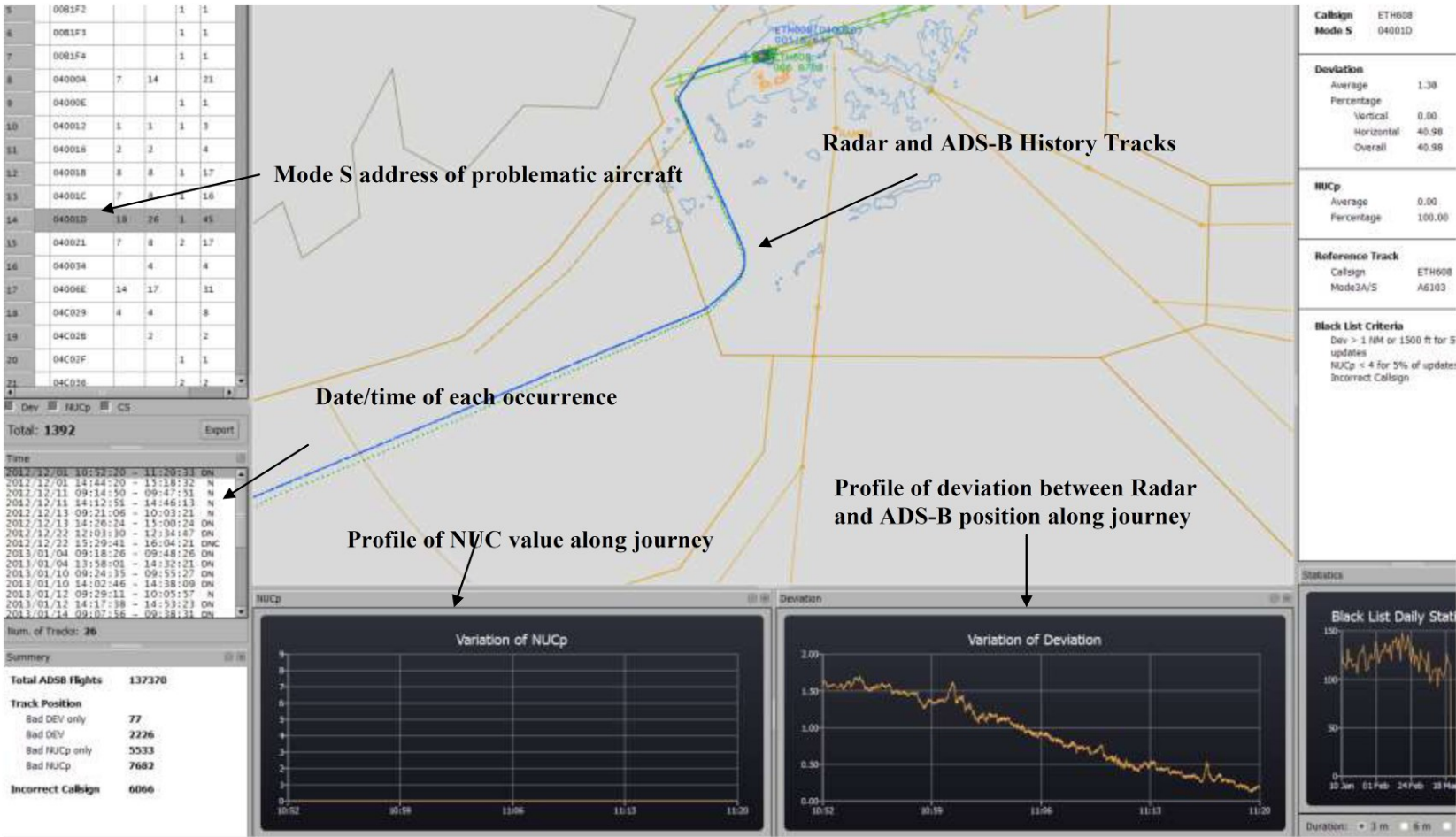


Figure 7d - IATA Airline Designator Code used

Attachment B - Sample screen shot of a system to monitor and analyse performance of ADS-B avionics



A Template for ADS-B Mandate/Regulations for Aircraft Avionics

- (1) On and after dd/mm/yyyy, if an aircraft carries 1090MHz extended squitter (1090ES) ADS-B transmitting equipment for operational use in xxxxxxxx territory, the equipment must have been certificated as meeting :¹
 - (a) 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
 - (b) 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
 - (c) Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems, or
 - (d) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.
- (2) On and after dd/mm/yyyy, if an aircraft operates on airways (insert routes).....at or above FLXXX.....(or in defined airspace boundaries at or above FLXXX):²

The aircraft must carry serviceable 1090MHz extended squitter (1090ES) ADS-B transmitting equipment that has been certificated as meeting :-

- (a) 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
 - (b) 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
 - (c) Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems, or
 - (d) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.
- (3) An aircraft carrying 1 090 MHz extended squitter (1090ES) ADS-B equipment shall disable ADS-B transmission unless:
 - (a) the aircraft emits position information of an accuracy and integrity consistent with the transmitted value of the position quality indicator; or
 - (b) the aircraft always transmits a value of 0 (zero) for one or more of the position quality indicators (NUCp, NIC, NACp or SIL); or

¹ This paragraph ensures all aircraft operating in the airspace, if equipped with ADS-B, are compliant to standards.

² This paragraph provides mandate requirements within certain parts of the airspace

- (c) the operator has received an exemption granted by the appropriate ATS authority.

Note: States are urged to include at least the standards stated in the template. States may include other standards allowed by the State's regulations.

**An Example of Advice to Operators Concerning Inconsistency Between ADS-B
Flight Planning and Surveillance Capability**

1 Background

Newer technologies for aircraft surveillance are now available – such as Mode S and ADS-B – which in many aircraft are installed as replacements for older Mode A/C transponders.

Air Traffic Control makes use of these new capabilities, and uses the Flight Plan information as a decision support tool – to allow the Air Traffic Controller to predict the surveillance capability of a particular aircraft before it enters radar or ADS-B coverage.

Requirements for ADS-B and Mode S (**insert local reference document if applicable**) may mean that if flight planning does not accurately reflect the aircraft capability, services may be withheld (for example if ADS-B is mandatory, but not indicated on the flight plan – **this section to be modified for local requirements**).

2 Flight Planning Requirements for Transponder and ADS-B

The flight planning requirements for aircraft are described in (**local document reference or ICAO DOC 4444 Appendix 2**) and repeated below.

Surveillance Equipment

N if no surveillance equipment for the route to be flown is carried, or the equipment is unserviceable

OR

INSERT one or more of the following descriptors, to a maximum of 20 characters, to describe the serviceable surveillance equipment and/or capabilities on board:

SSR Modes A and C

A Transponder — Mode A (4 digits — 4 096 codes)

C Transponder — Mode A (4 digits — 4 096 codes) and Mode C

SSR Mode S

E Transponder — Mode S, including aircraft identification, pressure-altitude and extended squitter (ADS-B) capability

H Transponder — Mode S, including aircraft identification, pressure-altitude and enhanced surveillance capability

I Transponder — Mode S, including aircraft identification, but no pressure-altitude capability

L Transponder — Mode S, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability

P Transponder — Mode S, including pressure-altitude, but no aircraft identification capability

S Transponder — Mode S, including both pressure altitude and aircraft identification capability

X Transponder — Mode S 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.

ADS-B

B1 ADS-B with dedicated 1 090 MHz ADS-B “out” capability¹

B2 ADS-B with dedicated 1 090 MHz ADS-B “out” and “in” capability¹

U1 ADS-B “out” capability using UAT

U2 ADS-B “out” and “in” capability using UAT

V1 ADS-B “out” capability using VDL Mode 4

V2 ADS-B “out” and “in” capability using VDL Mode 4

3 Additional information

The capability of your aircraft transponder, and ADS-B capability, will typically be available in the transponder manual, or in the aircraft flight manual for the aircraft. For General Aviation aircraft, the most common configurations for filing in the flight plan item10b will be (listed in order of capability).

EB1 – An ADS-B equipped aircraft would typically file this to indicate the Mode S transponder capability with ADS-B out.

S – The majority of Mode S transponders (without ADS-B) will support pressure altitude information and Flight ID transmission.

C – For aircraft with an older Mode A/C transponder – most of which provide pressure altitude capability.

Less common configurations in General Aviation will include:

¹ Based on current version of ICAO Doc 4444

H, LB1 or LB2 – Enhanced surveillance capability is more usually associated with higher end aircraft. ADS-B IN (B2) is relatively rare at this time, but may be available for some aircraft.

I, P or X – Most Mode S transponders will support Flight ID and pressure altitude, so these configurations are not common.

A – some low end GA aircraft may not provide pressure altitude information.

U1 or U2 – these ADS-B technologies are only authorized in a limited number of countries in the Asia Pacific Region.

Planning designations not to be used in Asia Pacific:

V1 or V2 – these ADS-B technologies are not authorised for use in Asia Pacific Region.

Remember:

Always flight plan the correct surveillance capability for your aircraft. If in doubt, consult the transponder manual, aircraft flight manual, or your Licenced Aircraft Maintenance Engineer.

Checklist of Common Items or Parameters for the Monitoring of ADS-B System

1 ADS-B Ground Station

Site Monitoring

- Receiver Sensitivity
- Antenna Cable
- GPS Health
- Coverage Check
- Probability of Detection
- Station Service Availability
- Receiver Status

Remote Control & Monitoring (RCMS)

- CPU Process Operation
- Temperature
- ASTERIX Output Load and Link Status
- Time Synchronization
- GPS Status
- Power Status
- Site Monitor Status
- Memory Usage
- Software Version (Operating System and RCMS Application)

Logistic Support Monitoring

- Record all failures, service outage and repair/return to service times

2 ADS-B Equipage Monitoring

- Update and maintain list of ADS-B equipped airframe details database
- Identify aircraft non-compliant to regional mandate

3 ADS-B Avionics Monitoring

- Track Consistency
- Valid Flight ID
- Presence of NACp/NIC/NUC Values
- Presence of Geometric Altitude
- Correctness of ICAO Aircraft Address

- Avionics Configuration and Connections
- Update and maintain list of aircraft with faulty avionics

4 ADS-B Performance Monitoring

- Percentage of aircraft with good integrity reports
- Accuracy of ADS-B Horizontal Position (Based on a reference sensor)
- Deviation between Geometric and Barometric Height
- Monitor the number of position jumps
- Message interval rate

5 ADS-B Display on ATC Display

- Split Track – ADS-B reported position might be off
- Coupling Failure – Wrong aircraft ID
- Duplicated ICAO Aircraft Address
- Display of data block

BASELINE ADS-B SERVICE PERFORMANCE PARAMETERS

The following table provides guidelines for various performance requirements of ADS-B Category (Tier) 1, 2 or 3 services that States may consider when acquisition of an ADS-B managed service agreement with a service provider:

Service Parameter	Guidance	Category 1 (Tier 1) 5Nm separation capable commensurate with Radars (separation/vectoring/high performance with reliability, integrity & latency)	Category 2 (Tier 2) Situational awareness similar to ADS-C (safety-net alerts, SAR, supports procedural separation without voice, not 5nm separation)	Category 3 (Tier 3) Position Reporting with Enhanced Flight Operation
Aircraft Updates	Recommended	0.5 second < Interval < 5 seconds as Operationally required	0.5 second < Interval < 20 seconds as Operationally required	0.5 second < Interval < 60 seconds as Operationally required
	Maximum	0.5 second < Interval < 10 seconds as Operationally required		
Network Latency	Recommended	95%: < 2 seconds of receiver-station output	95%: < 15 seconds of receiver-station output	95%: < 60 seconds of receiver-station output
Reliability 1	Recommended	2 autonomous receiver-stations including antenna, each providing data, no common point of failure	1 unduplicated receiver-station including antenna	1 unduplicated receiver-station including antenna
Reliability 2 - MTBF	Recommended	Each receiver-station including antenna to have MTBF >10,000 hrs	Each receiver-station including antenna to have MTBF >10,000 hrs	Each receiver-station including antenna to have MTBF >10,000 hrs
Reliability – Communications Infrastructure	Recommended	Completely duplicated, no common point of failure	Unduplicated, MTBF > 400 hrs	Unduplicated, MTBF> 200 hrs
Reliability – Total ADS-B Service	Recommended	Total Service MTBF >50,000 hrs	Total Service MTBF > 400hrs	Total Service MTBF> 200 hrs
Availability – Total ADS-B Service	Recommended	Total Service Availability > .999	Total Service Availability >.95	Total Service Availability >.90

Service Parameter	Guidance	Category 1 (Tier 1) 5Nm separation capable commensurate with Radars (separation/vectoring/high performance with reliability, integrity & latency)	Category 2 (Tier 2) Situational awareness similar to ADS-C (safety-net alerts, SAR, supports procedural separation without voice, not 5nm separation)	Category 3 (Tier 3) Position Reporting with Enhanced Flight Operation
Integrity – Ground Station	Recommended	Site monitor System Monitoring	Site monitor System Monitoring	System Monitoring
	Minimum	System Monitoring	Not required	Not required
Integrity – Data Communications & Processing	Recommended	All systems up to ATM system, errors < 1 x 10E-6	All systems up to ATM system, errors < 1 x 10E-6	All systems up to ATM system, errors < 1 x 10E-6

The choice of category (tier) could be based upon a number of factors including the following,

- a) The desired service
- b) The available budget
- c) The available ATC automation system & its capabilities and/or interim display systems
- d) ATC training and ratings
- e) Availability of appropriately tailored ATC procedures

States could initially choose one level and transition to another at a later time. For example, Category (Tier) 2 could be used to add additional safety nets/situational awareness and gain operational experience during the initial stage, moving later to a full separation service using Category (Tier) 1.

Note: The Performance Based Surveillance Sub Group of the ICAO Surveillance Panel is reviewing performance standards for surveillance systems generally. A future update to the requirements in the above table may be based on the outcomes of that panel.

**GUIDANCE MATERIAL ON
GENERATION, PROCESSING & SHARING of ASTERIX
CATEGORY 21 ADS-B MESSAGES
(Including Attachments A, B, C & D)**

1. INTRODUCTION

1.1 The “All Purpose Structured Eurocontrol Surveillance Information Exchange” (ASTERIX) Category 21 is a data format standard globally accepted by the Air Traffic Management (ATM) system manufacturing industry for sharing of ADS-B data with ATM automation system.⁸ Asterix Category 21 data is used to convey ADS-B data from ADS-B receiver stations to ATC processing and display system. This guidance material discusses various aspects of this process. Since the ASTERIX Category 21 edition 0.23 was issued in November 2003, it has undergone continuous revisions with some 19 subsequent editions. The focus of this guidance material is to concentrate on 1090ES ADS-B data using:

- a) RTCA DO-260 (Version 0);
- b) RTCA DO-260A (Version 1); and
- c) RTCA DO-260B (Version 2)

1.2 The ASTERIX Category 21 edition 1.0 issued in August 2008 fully incorporated the DO260A standard while edition 2.1 issued in May 2011 fully incorporated the latest DO260B standard. The latest edition (as at April 2018) is edition 2.4.

2. ASTERIX CAT 21 IN ASIA AND PACIFIC REGIONS

2.1 To ensure interoperability of ADS-B receiver stations in the Asia Pacific (ASIA/PAC) Regions, during the 16th APANPIRG Meeting held in August 2005, the ASTERIX Category 21 edition 0.23 which had incorporated DO260 standard was adopted as the baselined ADS-B data format for deployment of ADS-B receiver stations and sharing of ADS-B data in the ASIA/PAC Regions. At that time DO260A and DO260B standards were not defined.

3. CHOICE OF ASTERIX VERSION NUMBER

3.1 The Asterix standard has been developed over many years. Stability in the standard is desirable so that ADS-B receiver station designers and ATM automation designers and manufacturers can build interoperable systems with confidence. Because ADS-B technology has been evolving over the years, and will continue to do so, it is not surprising that the Asterix standard has also developed along with the ADS-B link technology standards to grasp the best benefits of its intended design.

3.2 During 2005, Asia Pacific decided to use Ed0.23 as the edition for sharing ADS-B data between states. This version provides adequate information so that useful ATC operational services can be provided including ATC 3 nautical mile and 5 nautical mile separation services. Ed0.23 can be used with DO260, DO260A and DO260B ADS-B avionics/receiver stations to provide basic ATC operational

⁸ FAA utilise Asterix Cat 33 for ADS-B message distribution.

services. However, Ed0.23 cannot fully support all the capabilities offered by DO260A and DO260B.

3.3 Nearly all Ed0.23 data items can be “re-constructed” from a received Ed2.1 data stream. However, most of the special DO260A/B data items cannot be “re-constructed” from an Ed0.23 data stream. In terms of domestic use and data sharing with other ANSPs concerning ADS-B data, several options exist for ANSPs as follows:

Option	Domestic use	Data sharing
1	Ed0.23	Ed0.23. This is the default and basic standard.
2	Ed2.1	Ed0.23. This will require some conversions to occur, probably through an ADS-B format conversion and filter system (see Paragraph 11), between a domestic system and a foreign system. Difficulties may exist if the domestic ATM system requires special DO260A/B data items, since they cannot all be re-constructed from the external foreign Ed0.23 data stream.
3	Ed2.1	Ed2.1. Must negotiate bilaterally with data sharing partner regarding exact version to be used to achieve the intended functions.

Note: In this table, Ed2.1, a later DO260B compliant Asterix Cat 21 edition, is chosen as a representation of an Asterix Cat 21 edition after Ed0.23. There exists other Asterix CAT 21 editions (e.g. 0.26, 1.3, 2.4 etc.) after Ed0.23 that could be used by ANSPs for domestic and data sharing use.

4. SPECIFICATION OF ASTERIX MESSAGE PROCESSING

4.1 Care is needed to understand the difference in specifications :

4.2 **Asterix Cat 21:** Defines the characteristics of the data ON the interface including fields that are mandatory on the interface.

4.3 **ADS-B receiver station specifications:** To define the Asterix standard, the ANSP must also define which optional Asterix data items are required to be delivered on the Asterix interface, when the appropriate data is received from the aircraft. It is desirable that suppliers be required to:

- a) indicate how the receiver station processes and outputs every received DO260, DO260A and DO260B data element into an Asterix data element/field; and
- b) indicate which and how each Asterix data element and field presented at the output are populated.

4.4 **ATM automation system specifications:** Defines which received Asterix data element and fields are processed and how they are processed. Also defines which Asterix optional data fields are required by the ATM automation systems (if any). ANSPs that specify ADS-B receiver stations and ATM automation systems need to consider carefully and clearly about what they desire to achieve. Specifications which simply require compliance with a particular Asterix edition will be inadequate in most circumstances. In particular ANSPs, together with their suppliers should :

- a) Specify the Asterix standard edition to be used. This defines the message formats that are placed on the link between ADS-B receiver station and downstream systems like ATM automation, recording & analysis systems, bypass ATC systems and foreign ANSPs. The edition will define which messages elements are mandatory in each message (very few fields) and a large number of optional fields. The optional fields can only be filled if relevant data is received from the aircraft. The optional fields will only be filled if the receiver station specification requires them to be filled.
- b) Specify the ADS-B receiver station behaviour so that when data is received from the aircraft, the receiver station is required to fill appropriate optional Asterix data fields.
- c) Specify the ATM automation system behaviour including appropriate semantic and syntax checks applied to the Asterix data, including any triggers for the system to discard data. The processing applied to each received Asterix data field should be specified. The ATC system should discard any messages with unexpected Asterix categories without discarding messages with known and defined Asterix categories.

5. MANDATORY FIELDS : ASTERIX AND 1090ES ADS-B

5.1 Asterix Cat 21 has been designed to support multiple datalinks. It has been defined to support data fields which are not available in the 1090ES standards. Therefore some data items and fields are not relevant when 1090ES is used.

5.2 The standard itself defines various items as optional or mandatory. This is defining what is ON the interface. It does NOT specify the behaviour of the transmitting receiver station nor the behaviour of the receiving ATM automation system.

5.3 When a single link technology has been chosen it may be sensible to diverge from the formal Ed0.23 standard to reduce the required Asterix datalink bandwidth. E.g.: in an environment with only 1090ES, it is unnecessary to transmit “Link Technology Indicator”. Asterix Cat 21 Ed 2.1 allows this selection.

Data Items	Description	Mandatory (M) or Optional (O) items as per ASTERIX Category 21	
		Version 0.23 Specification	Version 2.1 Specification
I021/010	Data Source Identification	M	M
I021/030	Time of Day	M	N/A
I021/071 or I021/073	Time of Applicability of Position or Time of Message reception for position	N/A	One of these is must be transmitted
I021/040	Target Report Descriptor	M	M
I021/080	Target Address	M	M
I021/210	Link Technology Indicator/MOPS version	M	O

6. GENERATION OF ASTERIX AT AN ADS-B RECEIVER STATION

6.1 The following general principles should be adopted:

6.2 Commensurate with link bandwidth availability, transmit all mandatory Asterix data items and also transmit those Asterix data items that are operationally desirable. That is, when the appropriate aircraft transmission is received by the ADS-B receiver station, the data should be transmitted to the ATC system for operational use or for technical recording and analysis use. If no aircraft transmission data is received to fill an Asterix data item during any update cycle, the data item should not be included in the Asterix data stream to reduce bandwidth requirements.

6.3 **Group 1 (Mandatory Data Items):** An Asterix Cat21 message should not be transmitted unless the mandatory data items defined in Appendix A are all present.

6.4 **Group 2 (Desirable Data Items) :** The data items defined in Appendix B are operationally desirable which should always be transmitted in the Asterix Cat 21 messages whenever the data are received by the 1090ES receiver station from aircraft (if allowed by the relevant Asterix standard chosen).

6.5 **Group 3 (Optional Data Items) :** The data items defined in Appendix C are considered optional and may or may not need to be transmitted depending on availability of such data from aircraft and/or other specific operational needs.

6.6. **Group 4 (Future Data Items):** The following data are defined in the DO260A and DO260B standards but are not yet defined in the Asterix standard. This group is provided for information only. It illustrates the need for system designers to provide for future adaptability when possible and when cost effective to do so. Not only will the Asterix standard continue to evolve, but changes to DO260 can also be anticipated within the decade.

- a) Target heading: Information from DO260A/B Target state and status messages (On condition messages). These could be used for detection of pilot

errors in selection of heading/altitude; and

- b) GPS Offset: Could be used to more accurately display aircraft position on an airport surface, or better detect that an aircraft has passed an airport hold point.

6.7 When developing a specification for an ADS-B receiver station, it is considered necessary that the specification requires the transmission of all data items that are operationally desirable (Group 2), when such data are received from the aircraft, in addition to the data items that are mandatory (Group 1) in Asterix messages. Whether Group 3 optional data items will need to be transmitted or not should be configurable on item-by-item basis within the ADS-B receiver station depending on specific operational needs.

7. PROCESSING OF ASTERIX ADS-B DATA AT THE ATC SYSTEM

7.1 An Asterix Cat21 message should not be accepted by the ATC system for processing unless it includes at least all the Group 1 data items.

7.2 The ATC system should process all received Asterix Cat21 message data items that bring operational benefits (i.e. Group 2 data items). An ATM automation specification should require that the system appropriately process those Group 2 data items depending on specific operational need. Whether the ATC system will process Group 3 optional data items will depend on specific operational needs.

8. DATA SHARING OF ASTERIX ADS-B DATA

8.1 In principle, all data receiving from the shared ADS-B receiver station should be delivered to the receiving party as far as practicable without filtering, unless owing to technical reasons such as the need to convert the data from one ASTERIX format to another, or it is requested by the receiving party of the data.

8.2 It is considered necessary that all data items that are mandatory in Asterix messages (i.e. Group 1 data items) and operationally desirable (i.e. Group 2 data items) when such data are received from aircraft, should be included in data sharing. In the event that the data have to be filtered, the list of optional data items (i.e. Group 3 data items) needs to be shared will be subject to mutual agreement between the two data sharing parties concerned.

9. ISSUE RELATED TO DO260A

9.1 Support of DO260A using Asterix Cat 21 Ed0.23

- a) DO260A was developed after Ed0.23 of Asterix was defined. Therefore, Ed0.23 does not directly support DO260A. However, receiver station software can generate useful Ed0.23 Asterix data from DO260A reports through use of the following techniques;

- b) A useful I021/090 Figure of Merit can be generated from DO260A messages. Some implementations have a table, which defines the FOM/PA to be generated for each combination of SIL, NIC and NAC. The contents of the table can be offline defined to generate the appropriate FOM/PA values. The downstream ATC system can then process DO260A reports as if they were DO260 reports; and
- c) If there is a particular need for the ATC system to have access to the NIC/NAC or SIL or other data item that exist in DO260A (but not in DO260), then users may need to consider a more recent version of Cat 21.

9.2 Support of DO260A using Asterix Cat 21 Ed 1.0 or Ed2.1 (or later versions)

- a) When DO260A is used, then the ANSP could decide to use Asterix Cat 21 Ed1.0 (or later versions) or Ed2.1 (or later versions); and
- b) Readers are invited to carefully examine the DO260A fields (see Appendix D) to determine if the benefits of additional DO260A fields are large enough to warrant adoption of Asterix Cat 21 Ed1.0 (or later versions) or Ed2.1 (or later versions).

10. ISSUE RELATED TO DO260B

10.1 Support of DO260B using Asterix Cat 21 Ed0.23

- a) DO260B was developed some years after DO260A. Therefore, Asterix Cat 21, Ed0.23 does not directly support DO260B;
- b) The same techniques used for processing DO260A can be used for processing DO260B, however, the table used must account for NIC supplement B & NIC supplement C, and may also wish to account for SDA; and
- c) If there is a particular need for the ATC system to have access to the new data items offered by DO260B, then users may need to consider a more recent version of Cat 21 (e.g. Ed2.1 or later versions).

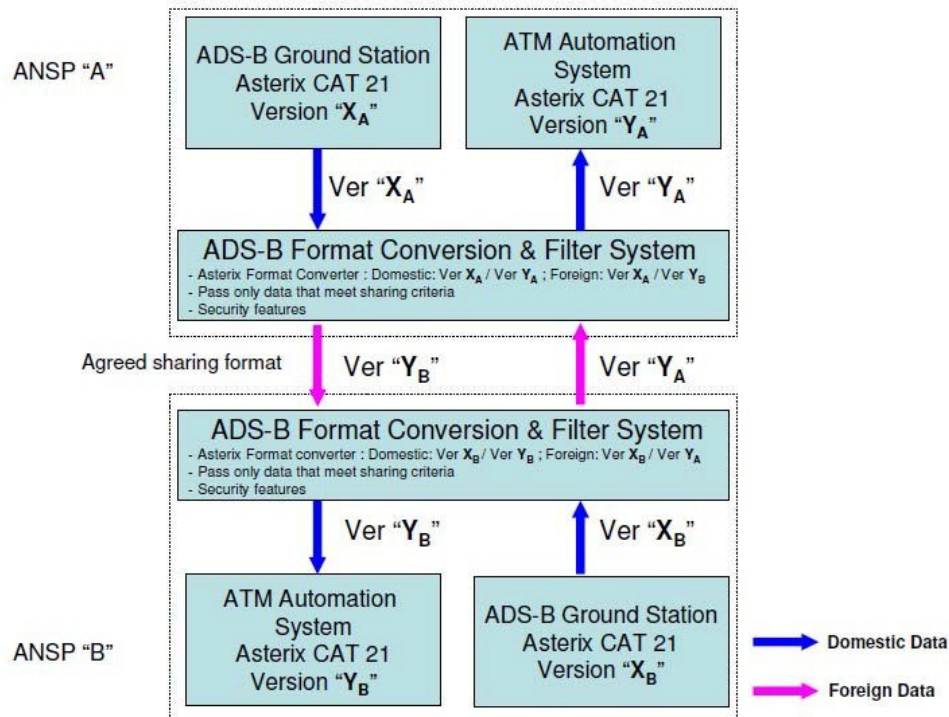
10.2 Support of DO260B using Asterix Cat 21 Ed2.1 or later versions

- a) If DO260B is used, then the ANSP could decide to use Asterix Cat 21 Ed2.1 or later; and
- b) Readers are invited to carefully examine the DO260B data items (see Appendix D) to determine if the benefits of additional DO260B data items are large enough to warrant adoption of Asterix Cat 21 Version 2.1 or later.

11. ADS-B FORMAT CONVERSION AND FILTER SYSTEM

11.1 It is clear that the evolution of 1090ES ADS-B transmission will continue. Avionics software will be upgraded to provide additional or changed functionality. As a result Asterix standards will also continue to evolve, and ATC systems will need to be adaptable to be able to cope with new functionality requirements and new message standards.

11.2 The use of an ADS-B format conversion & filter (ADS-B FC&F) system between domestic ADS-B systems and data shared with other states is a cost-effective way to provide the necessary protection and flexibility in this evolution. Such a system provides ADS-B format conversion between domestic and foreign ADS-B systems. While decoupling one ADS-B Asterix environment from another, the system allows information that meets specific sharing criteria to be passed through for data sharing. By doing so, loading on the ATM automation systems to process ADS-B data and bandwidth requires to transmit the ADS-B data could then be reduced. The system also allows independent domestic format changes without disruption to the foreign environment. A typical structure could be as shown below:



7 Attachment A - Group 1 (Mandatory Data Items)

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/010	Data Source Identification	X	X	Identifies source of data. Important if validity checks are performed as an anti spoofing capability. Validation that the data is received from an approved ADS-B receiver station. Data received from a receiver station should not be processed if the position of the reported aircraft is an unreasonable distance away from the known location of the ADS-B receiver station. Where space based ADS-B is used and a nominal station location is defined, such range processing limits will need to account for the coverage supplied.
I021/030	Time of Day	X		Necessary to extrapolate the ADS-B data to time of display. Data received with a Time of Day too far in the past should be discarded. This data is too old.
I021/071 or I021/073	Time of Applicability of Position or Time of Message reception for position		X	Necessary to extrapolate the ADS-B data to time of display. Data received with a Time of Day too far in the past should be discarded. This data is too old.
I021/040	Target Report Descriptor	X	X	Indicates if report is a duplicate, on the receiver, is a simulated target, is a test target. This needs to be checked by ATC system prior to processing. If the data indicates that the report is a test target or a simulated target, it is normally processed differently to "real" targets.
I021/080	Target Address	X	X	Included in all 1090ES downlink messages, so always available. Used for report/report linkage in ATC tracking.
I021/090	Figure of Merit/Quality Indicators	X	X	Position cannot be used without quality indicator. If the quality of the positional data does not meet the requirements the data should be discarded.
I021/130	Position in WGS-84 co-ordinates	X	X	Report cannot be used without position

Attachment B - Group 2 (Desirable Data Items)

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/008	Aircraft operational status		X	TCAS capability, Target state reporting capability, CDTI capability, Single/dual aircraft antenna. It is desirable to have immediate knowledge of RA event.
I021/020	Emitter Category	X	X	Aircraft or vehicle type
I021/140	Geometric Altitude/Height	X	X	Useful for RVSM monitoring. Not normally used for ATC application. Could perhaps be used as an indicator of correct QNH setting in aircraft.
I021/145	Flight Level	X	X	Flight level is an important information to ATC
I021/155	Barometric Vertical Rate	X	X	Used for predictive tools and safety nets. Either Barometric vertical rate or Geometric vertical rate is provided by the aircraft – not both. However, the ATC system can calculate vertical rate from multiple flight level reports if these data items are not available.
I021/157	Geometric Vertical Rate	X	X	
I021/160	Ground Vector	X	X	Provides excellent vector to support extrapolation of positional data to time of display. However, the ATC system can calculate the velocity vector (ground vector) from multiple position reports. I021/160 however, is normally far superior than ATC system calculation.
I021/170	Target Identification	X	X	This is the callsign/Flight ID is extremely useful for ATC and matching to the flight plan (if any). Target identification is only sent once per 5 seconds. Some receiver stations designs attach the target identification (if known from previous recent downlinks) even if not received in the last 5 seconds. The field can be missing at the edge of ADS-B coverage – for flights inbound to coverage.

I021/200	Target Status	X	X	This is the emergency type and is highly desirable.

Attachment C - Group 3 (Optional Data Items)

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/077	Time of report transmission		X	Time of applicability is relevant for ATC system processing. Time of transmission is less relevant.
I021/032	Time of Day Accuracy	X		Maximum error in Time of day. Normally the maximum value is known by the ANSP because of station design.
I021/095	Velocity Accuracy	X		If using GPS, velocity accuracy will be adequate if the Position quality is accurate.
I021/072	Time of applicability of velocity		X	Can be managed by a velocity data time out in receiver station.
I021/075	Time of message reception of velocity		X	Normally velocity is in the same Asterix message as position. Velocity data time out in receiver station.
I021/161	Track number		X	Tracking can be performed by ATC system. Also the 24 bit code (aircraft address) could be used as a pseudo track number.
I021/110	Trajectory Intent	X	X	Defined in DO260 but not transmitted by any known product. Not defined in DO260A or DO260B
I021/146	(Intermediate) Selected Altitude	X	X	Target altitude : Information from DO260A/B Target state and status messages (On condition messages). These could be used for detection of pilot errors in selection of heading/altitude.
I021/148	Final State Selected Altitude	X	X	
I021/015	Service identification		X	Type of Service (VDL4, Ext Squitter, UAT, TIS-B VDL4, TIS-B Ext Squitter, TIS-B UAT, FIS-B VDL4, GRAS VDL4, MLT). Not useful to most ATC systems.
I021/016	Service management		X	Update rate or whether data driven output from GS. Normally known by receiver.

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/074	Time of message reception of position – high resolution		X	High resolution is designed to support MLAT system processing by receiver. Not required for pure ADS-B.
I021/076	Time of message reception of velocity – high resolution		X	High resolution is designed to support MLAT system processing by receiver. Not required for pure ADS-B.
I021/210	MOPS version/ Link Technology Indicator	X	X	Maybe useful for statistics about equipage. Not operationally relevant
I021/070	Mode 3/A code		X	Could be used for legacy ATC system that do not use Flight ID
I021/165	Rate of Turn/Track Angle rate	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/271	Surface capabilities and characteristics		X	
I021/132	Message amplitude		X	Useful for technical analysis. Not operationally relevant
I021/250	Mode S MB data		X	
I021/260	ACAS resolution advisory report		X	
I021/400	Receiver ID		X	
I021/295	Data ages		X	
I021/150	Air Speed	X	X	Defined in standards but only sent in absence Ground vector information. Can't be used for extrapolation unless wind speed known.
I021/151	True Air Speed	X	X	
I021/152	Magnetic Heading	X	X	Defined in standards but only sent in absence Ground vector information.
I021/220	Met Report	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/230	Roll Angle	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/131	Position in WGS-84 coordinates, high resolution		X	

Attachment D - Differences among DO260, DO260A, DO260B

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Introduction of Navigation Integrity Category (NIC) to replace Navigation Uncertainty Category (NUC _P)	NUC _P is used.	NIC is used to replace NUC _P .	More levels of NIC available. Vertical component removed.	NIC is shown in Ed1.0 and above. More levels of NIC (shown as PIC) are available in v2.1.	The additional quantum levels of NIC would allow the ANSP more flexibility in deciding whether the NIC is considered as 'good' (if required) However, for 3 NM & 5 NM separation with HPL 1Nm and 2 Nm respectively, this additional quantum is not useful.
Quality Indicator for Velocity (NUC _R and NAC _V)	NUC _R is used.	Replaced with NAC _V . Definition remains the same.	Vertical component removed.	Available in Ed0.23 and above.	Vertical component is not available for DO260B.
Surveillance Integrity Level and Source Integrity Level (SIL)	Not available.	Surveillance Integrity Level is used.	Renamed as Source Integrity Level. Definition is changed to exclude avionics fault.	Available in Ed1.0 and above.	The SIL will allow the user to further assess the integrity of the reported position (if required). NB: An implied SIL exists for DO260 aircraft if they always use GPS. However DO260 aircraft do not provide SIL.
System Design Assurance (SDA)	Not available.	Not available.	To address probability of avionics fault.	Available in Ed2.1.	The SDA will indicate the robustness of the system. ANSPs may decide on a minimum SDA for ADS-B services. If this action is taken then DO260 and DO260A aircraft will be unable to meet the criteria.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Navigation Accuracy Category (NAC _P)	Not available.	Derived from HFOM and VFOM.	Relies only on HFOM.	Available in Ed1.0 and above.	A reported accuracy is not provided by DO260. However, an estimated accuracy can be derived from NUC – assuming that NUC is HPL based.
Geometric Vertical Accuracy (GVA)	Not available.	Not available.	Derived from VFOM.	Available in Ed2.1.	Geometric altitude accuracy is not normally required for operational purposes.
Barometric Altitude Integrity Code (NIC _{BARO})	Not available.	To indicate integrity of barometric altitude.	Same as DO-260A	Available in Ed1.0 and above.	The NIC _{BARO} indicates the integrity of the barometric height. ANSPs could indicate to the controller that Barometric data has not been verified, however, aircraft without dual barometric systems/air data computers may be unable to provide a non zero NIC _{BARO} as data could be unnecessarily discarded.
Length / Width of Aircraft	Not available.	Provide an indication of aircraft size.	Same as DO-260A	Available in Ed1.0 and above.	The width / length indicate the size of the aircraft. This information may be used as an input for generating alerts on airport surface movement control.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Indication of capabilities	Only show status of TCAS and CDTI.	More information available including capability to send Air Reference Velocity, Target State and Trajectory Change reports. Status of Identity Switch.	Additional information on type of ADS-B in (i.e. 1090ES in or UAT in).	Available in Ed1.0 and above, except availability of 1090ES/UAT in and information on GPS antenna offset.	Indication on the availability of 1090ES in / UAT in may allow the controller to anticipate a potential request for in-trail procedure clearance. NB: ITP requires decision support aids which are more complex than ADS-B IN alone.
Status of Resolution Advisory	Not available.	Information on whether Resolution Advisory is active.	Same as DO-260A	Available in Ed1.0 and above,	Indication of the resolution advisory status allows the controller to know whether the pilots were alerted about the potential conflict.
GPS offset	Not available.	Indication on whether GPS offset is applied.	Information on GPS antenna offset is provided.	GPS offset status is available in Ed1.0 and above. Information on GPS offset is not available in ASTERIX	Indication on GPS offset may be one of the inputs for generating alerts on airport surface movement control.
Intention	Not available.	Able to indicate intended altitude and heading.	Same as DO-260A	Intended altitude is available in Ed0.23. Intended heading is not available in ASTERIX.	The intended heading and flight level can be used as an input to the trajectory prediction algorithm in the Short-Term Conflict Alert.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Target Status	Not available.	Not available.	Indication of Autopilot mode, Vertical Navigation mode, Altitude Hold mode, Approach Mode and LNAV Mode.	Vertical Navigation mode, Altitude Hold mode and Approach Mode are available in Ed 0.23 and above LNAV Mode is available in Ed2.1	The target status allows the controller to know the mode that the aircraft is in. i.e.: It could be presented to ATC.
Resolution Advisory	Not available.	Not available.	Availability of Active Resolution Advisories; Resolution Advisory complement record, Resolution Terminated; Multiple Threat encounter; Threat Type indicator; and Threat Identity data.	Available in Ed1.0 and above.	The Resolution Advisory will help the controller know the advisories that are provided to the pilots by the ACAS. This helps prevent the controller from giving instructions that are in conflict with the ACAS.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Mode A	DO260 change 1, allows this using test message in USA only. This was not implemented in actual products.	Broadcasted using test message in USA only.	Broadcasted worldwide as a regular message.	Available in Ed0.26 and above.	The Mode A allows flight plans to be coupled with the ADS-B tracks (supports legacy ATM automation system).

Appendix 8

ATTACHMENT to State letter SP 44/2-19/77

GUIDANCE ON 1 090 MHZ SPECTRUM ISSUES AND PROPER MANAGEMENT OF 24-BIT AIRCRAFT ADDRESSES ASSOCIATED WITH UNMANNED AIRCRAFT (UA)

Note. — This document is an unedited advance version of an ICAO publication as approved in principle, by the Secretary General, which is made available for convenience. The final edited version will be included in the next amendment to the Aeronautical Surveillance Manual (Doc 9924), which will be published in due course.

1. Background

1.1 The frequencies 1 030 and 1 090 MHz, acting as a frequency pair, support several aeronautical surveillance systems including secondary surveillance radar (SSR), multilateration (MLAT), airborne collision avoidance systems (ACAS) and automatic dependent surveillance-broadcast (ADS-B). Aircraft are interrogated by ground SSR/MLAT (or other aircraft, in the case of ACAS) on 1 030 MHz and reply (or broadcast) on 1 090 MHz with information such as their position, altitude and velocity vector.

1.2 The increasing density of ground-based and on-board surveillance systems using the 1 030/1 090 MHz frequencies is currently raising concerns, especially in dense airspaces. Ultimately it may result in a reduction to the overall performance of ACAS as well as the SSR/MLAT and ADS-B systems. In addition, the increased usage of ADS-B OUT applications for safety of life services and potential future evolution of those applications, such as space-based ADS-B, have raised serious concerns of potential congestion at 1 090 MHz. To ensure continued safe operation for all aircraft, proper and efficient utilization of available bandwidth at 1 090 MHz is required. This may include, when necessary, limiting access to 1 090 MHz by certain users.

1.3 Furthermore, it is important to note that those aeronautical surveillance systems rely on a limited capacity 24-bit aircraft address scheme. The allocation of a 24-bit aircraft address and its correct configuration in aircraft is a key element for safe operation of aircraft and associated protocols used to support communication and surveillance systems.

1.4 As defined in Annex 10 — *Aeronautical Telecommunications*, Volume III — *Communication Systems*, aircraft addresses are allocated in blocks by ICAO to the State of Registry or to the common mark registering authority. Using its allocated block of addresses, the State of Registry or the common mark registering authority assigns an individual aircraft address to each suitably equipped aircraft entered on a national or international register.

1.5 It is essential for States to recognize that their allocated block of 24-bit aircraft addresses is a finite and valuable asset. There are only 16 777 214 aircraft addresses in total and many of those have already been allocated to States of Registry or common mark registering authorities. Aircraft traffic growth has been forecast to double in the next 15 years and to manage these addresses in a sustainable manner, States need to validate whether new aircraft address allocation requests by aircraft operators fit the conditions defined in Annex 10, Volume III.

2. Issues identified in relation to operation of unmanned aircraft

2.1 As described above, concerns are being raised about congestion of the 1 090 MHz frequency and shortage of 24-bit aircraft addresses. The rapid growth in the number of UA is making those concerns more severe.

2.2 Exponential increase of the safety risk due to 1 090 MHz congestion

2.2.1 A recent study indicates that large numbers of UA (one UA per 2 square kilometres) operating at low level (less than 500 feet above ground level) in a typical high-density terminal airspace (760 ADS B-equipped aircraft operating within a 200 NM radius and from ground level to FL180) can

interfere with ADS-B ground station reception of ADS-B reports when the transmit power of each UA is 1 watt or higher.

Note. — Some other studies indicate that even a low power (0.1W) transmission from large numbers of UA can reduce the coverage range of ADS-B.

2.2.2 All studies reviewed conclude that the operation of ADS-B OUT by a large number of UA raises a serious concern for the safety of other aircraft in the same airspace.

2.3 Future depletion of 24-bit aircraft addresses

2.3.1 The 24-bit aircraft address scheme was not designed for a very large number of aircraft. Some studies predict that based on the present growth of UA, there will be over a million such vehicles by 2025. Based on these current projections, it will be impossible to accommodate all UA in the current scheme.

2.3.2 In some situations UA may require a 24-bit aircraft address, for instance if the UA fly in controlled airspace or in proximity to traditional manned aircraft. States will need to evaluate such situations on a case-by-case basis when receiving a new aircraft address application from the UA community.

Note. — As described in the Manual on Remotely Piloted Aircraft Systems (RPAS) (Doc 10019), an aircraft which is intended to be operated with no pilot on board is classified as unmanned and an unmanned aircraft which is piloted from a remote pilot station is a remotely piloted aircraft (RPA) (refer to the following figure).

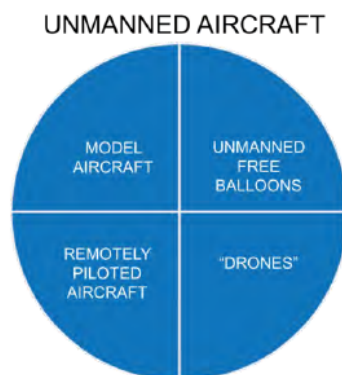


Figure 1-1 Unmanned aircraft

3. Procedure to ensure proper utilization of 1 090 MHz and for non-allocation of (24-bit) aircraft address for UA

3.1 There is increasing pressure to use 1 090 MHz Mode S or ADS-B OUT applications by UA. Given the large forecasted increase of UA and the fact that transmissions from their transponders or ADS-B OUT devices will impact the already congested use of 1 090 MHz by existing aeronautical surveillance and collision avoidance systems, States are urged to:

- 1) perform radio frequency spectrum analysis to analyse the degree of congestion of 1 090 MHz and, based on the outcome of this analysis, consider how 1 090 MHz ADS-B UA operations might impact the performance of the air navigation service provider (ANSP)-operated surveillance

systems in airspace of interest as well as the automatic collision avoidance systems on board aircraft operating in that airspace;

- 2) formulate the circumstances and define procedures to determine the potential requirement for 1 090 MHz ADS-B OUT equipage on UA in order to allow or prohibit such equipage as appropriate. During this process, States should consider:
 - the degree to which individual UA may or may not require air traffic services. For example, a UA operating in uncontrolled airspace may not be required to use ICAO-compliant aeronautical surveillance systems; and
 - the degree to which the operation of individual UA may or may not interoperate in the airspace with traditional manned aircraft. For example, if UA are not operating in proximity to traditional manned aircraft, then the use of ICAO-compliant aeronautical surveillance equipment by UA may not be justified.
- 3) in cases where UA are not required to equip with ICAO-compliant aeronautical surveillance equipment, States should not allocate 24-bit aircraft addresses.

Note. — 24-bit aircraft address allocation should be a part of the UA registration or operator approval process. For guidance material on reliable usage of 24-bit aircraft addresses, refer to Annex 10, Volume III and Doc 9924.

CNS SG/26

Appendix J to the Report



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

**AIR TRAFFIC MANAGEMENT AUTOMATION SYSTEM
IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT**

Edition 1.0-June 2022

AMENDMENTS

The issue of amendments is announced, when an amendment has been agreed by a meeting of the ICAO Asia/Pacific Air Traffic Management Automation System Task Force (APAC ATMAS TF). The space below is provided to keep a record of such amendment.

RECORD OF AMENDMENTS

Amendment Number	Date	Amended by	Comments
0.0	Feb 2020	China	The framework of this document is firstly work out by China.
0.1	Sep 2021	China, Hong Kong China, Philippines	First completed draft based on the agreed document framework in ATMAS TF/1 for review and comment by States
1.0	Jun 2022	China, Singapore, Hong Kong China	Revised the draft according to the inputs from States.

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ACRONYMS AND ABBREVIATIONS

ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
ADEXP	ATS Data Exchange Presentation
AFTN	Aeronautical Fixed Telecommunications Network
AIDC	ATS Inter-facility Data Communication
AGDL	Air Ground Data Link
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
APP	Approach Center
APM	Approach Path Monitoring
APW	Area Proximity Warning
A-SMGCS	Advanced Surface Movement Guide Control System
AST	Approach Spacing Tool
ASTERIX	All-purpose Structured EUROCONTROL Radar Information Exchange Protocol
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMAS	Air Traffic Management Automation System
ATO	Actual Time Over
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
AWOS	Automatic Weather Observation System
BSDP	Bypass Surveillance Data Processing
CA	Conflict Alert
CFL	Cleared Flight Level
CLAM	Cleared Level Adherence Monitoring
CPDLC	Controller-Pilot Data Link Communications
CRC	Cyclic Redundancy Check
CWP	Controller Working Position
DAP	Downlink Aircraft Parameter
DBS	Distance-based Spacing
DCL	Data Link Departure Clearance
DMAN	Departure Management
DPM	Departure Path Monitoring
ELDT	Estimated Landing Time
ETO	Estimated Time Over
ETO	Expected Time Over
EUROCONTROL	European Organization for the Safety of Air Navigation
FAA	Federal Aviation Administration
FDP	Flight Data Processing
FIR	Flight Information Region
GNSS	Global Navigation Satellite System

GRIB	Processed Meteorological Data in the Form of Grid Point Values Expressed in Binary Form
HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
LAN	Local Area Network
METAR	Aerodrome Routine Meteorological Report(in Meteorological Code)
MSAW	Minimum Safe Altitude Warning
MSP	Maintenance Service Provider
MTCD	Medium Term Conflict Detection
NTP	Network Time Protocol
NTZ	No Transgression Zone
PBN	Performance Based Navigation
PCA	Predicted Conflict Alert
PDC	Pre-Departure Clearance
PMON	Position Report Monitoring
PSR	Primary Surveillance Radar
QNH	Altimeter Sub-scale Setting to Obtain Elevation When on the Ground
RAM	Route Adherence Monitoring
RVSM	Reduced Vertical Separation Minimum
SCA	Similar Callsign Advisory
SDP	Surveillance Data Processing
SID	Standard Instrument of Departure
SMAN	Surface Management
SMD	Software Management Department
SP	System Supplier
SPI	Special Position Identification
SSR	Secondary Surveillance Radar
STAR	Standard instrument Arrival
STCA	Short Term Conflict Alert
TBS	Time-based Spacing
TLDT	Target Landing Time
UTC	Universal Time Coordinated
VSP	Variable System Parameter
WAM	Wide Area Multilateration

1. INTRODUCTION

1.1 Purpose

Since the Air Navigation Conference held in 2012, ICAO has been exploiting a global roadmap in the Aviation System Block Upgrades (ASBU) under its Global Air Navigation Plan (GANP), with a focus on harmonization and interoperability leading to a global Air Traffic Management (ATM) system.

Following the framework of GANP and the timeline of ASBU, the Asia/Pacific Seamless ATM Plan was adopted by the 24th Meeting of the Asia/Pacific Planning and Implementation Regional Group (APANPIRG/25) in 2013. It defines goals and the means of meeting State planning objectives for a Regional seamless ATM performance framework, focusing on technological and human performance.⁴

To facilitate and harmonize the provision of robust, safe, efficient and orderly ATM services in the region, it is considered necessary to develop regional guidance materials with recommendations on the development and implementation of Air Traffic Management Automation System (ATMAS).

This Air Traffic Management Automation System Implementation and Operations Guidance Document (ATMAS IGD) provides guidance for the planning, design, testing, and implementation of the ATMAS in the Asia and Pacific Regions, with the purpose of ensuring continuous and coherent development of the ATMAS that is harmonized with adjacent regions.

The system requirements and operational procedures for the ATMAS are detailed in the relevant States' projects and AIP. This ATMAS IGD is intended to provide guidelines on the primary and the most important function as well as performance requirements of the ATMAS, based on the operations and maintenance practices.

1.2 Background

1.2.1 ATM Operational Concept

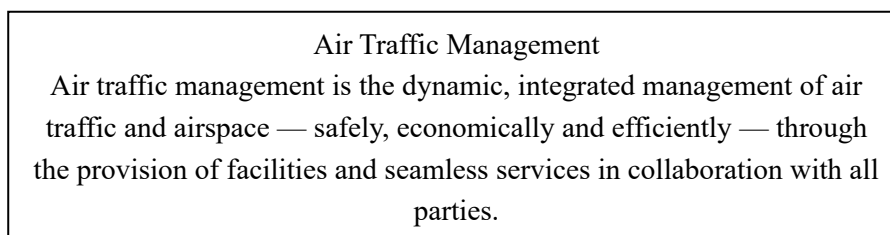
The global ATM operational concept presents the ICAO vision of an integrated, harmonized, and globally interoperable ATM system. The planning horizon is up to and beyond 2025. The baseline against which the significance of the changes proposed in the operational concept may be measured is the global ATM environment in 2000.

Vision Statement

To achieve an interoperable global air traffic management system, for all users during all phases of flight, that meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements.

While the operational concept is visionary and even challenging, many current practices and processes will continue to exist through the planning horizon. In this sense, this operational concept document should be seen as evolutionary.

A key point to note is that the operational concept, to the greatest extent possible, is independent of technology; that is, it recognizes that within a planning horizon of more than twenty years, much of the technology that exists or is in development today may change or cease to exist. This operational concept has therefore been developed to stand the test of time.



1.2.2 ATM System and Its Sub-system

The objective of ATM is to provide safe, economic, efficient, and dynamic management of air traffic and airspace that includes Air Traffic Service (ATS), Air Traffic Flow Management (ATFM), and Airspace Management (ASM), as shown in Figure 1.2.2-1.

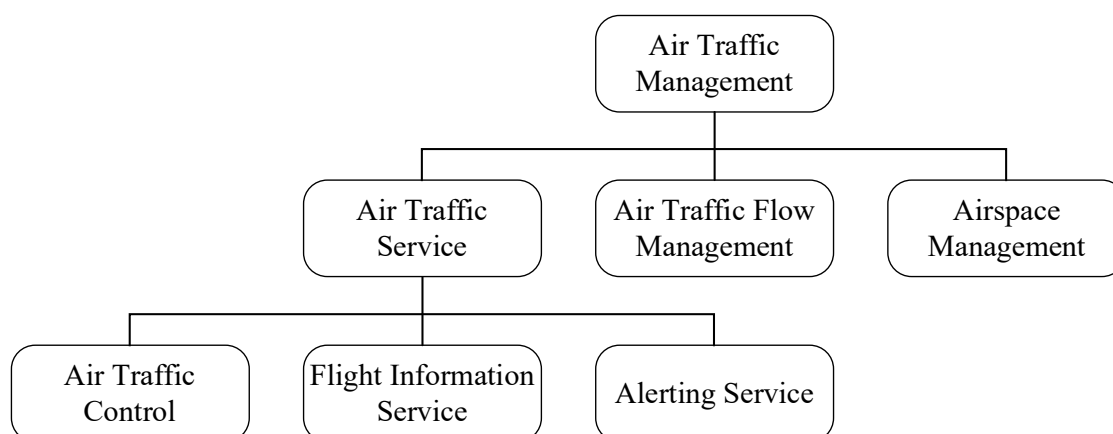


Figure 1.2.2-1 Composition of air traffic management

ATS is the central part of ATM, which includes Air Traffic Control (ATC), Flight Information Service (FIS), and Alerting Service (ALRS).

The Objective of:

- a. ATC is to prevent collisions between aircraft and, on the maneuvering area, collisions between aircraft and obstructions. ATC also expedites and maintains the orderly flow of traffic.
- b. FIS is to give advice and information useful for the safe and efficient conduct of flights.
- c. ALRS is to notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required.

1.2.3 Concept of ATMAS

The ATMAS mentioned in this document is mainly applied in ATC service, and offers assistance for ALRS and ATFM. It comprises a group of processing sub-systems dedicated to specific functions, which are integrated as one air traffic management system to provide functional capabilities to air traffic controllers in the Area Control Centers (ACC), Approach Control Unit, and Aerodrome Control towers. The ATMAS helps controllers keep conformance monitoring, hazard monitoring, and assuring safety separation to air traffic flow.

The ATMAS has a modular design and distributed architecture to ensure robustness under adverse operating conditions. The modularity enables modifications to the baseline product to be made with relative ease. The principle of distributed processing ensures the safe, uninterrupted provision of Air Traffic Services by controllers.

All processing and display sub-systems are interconnected via high-capacity redundant LANs. Computers providing common services (e.g., Flight Data Processing) may be duplicated, with each computer connected to each LAN providing a high degree of redundancy. Fail safe operation of the dual computer groups is achieved by multiple computation redundancy (parallel operation of the computer), or hot stand-by redundancy, to provide uninterrupted service to the controllers.

Typically, considering the safety and redundancy requirements, the ATMAS has two individual LANs, which are called working LANs, where the redundancy computers are connected. The working LANs keep sharing information and function as main and fallback modes. Air traffic control airspace with high-density traffic is recommended to use a third LAN, which is called service LAN. The latter's primary function is system trace collection, handling of recording and playback, etc.

1.2.4 Challenges and Solutions

Considering the framework for global ATM roadmap requirements and the current world situation, ATMAS is facing the following challenges:

- a. The challenge for States to implement technologies as prescribed in the GANP and ASBU timeframes particularly is innovative concepts such as 4D trajectory and seamless ATM across FIRs. The seamless ATM Plan requires the individual ATMAS sharing a common set of accurate information in a timely manner, which needs to interface with each other seamlessly and work interoperability.
- b. Traditional ATMAS procurement processes deliver systems that are not COTS but a baseline of core function and subsequent accumulation of bespoke design for previous ANSP applications. As the system functions and features continue to develop, the system is getting more and more complex. These cause long software/application development and practically, in most cases, these functions/features are seldom used. Consequently, the system is getting hard to maintain and costly to deploy.
- c. Increase scrutiny of costs for ANSPs due to various reasons, including airspace user scrutiny, public oversight into spending, or constrained national budgets due to local or regional economic events. Significantly, public health emergencies have a devastating impact on the economy and the aviation industry worldwide. It will not be surprising that the ICAO member states, including those in the APAC Region, must reappraise both their capital and operational expenses (CAPEX and OPEX) in the coming years, including the expenditure in the ATMAS.

To overcome the above challenges, it is important to come up with the ATMAS IGD that will provide the main functions and performances which is aimed at facilitating the implementation or provision of the robust, safe, efficient ATM automation systems. This will help the APAC region member states/CAAs/ANSPs to have an ATM automation system that shares common/core functions/performances while achieving seamless interoperability rather than investing more on CAPEX/OPEX to cope with future increase in air traffic. It is relatively more important to put focus on:

- a. application of new/innovative technologies that would help make good business cases,
- b. incorporating baseline/key optional features into their system design at an early stage, and
- c. preparing for system completion affecting changes during low air traffic periods before full traffic recovery.

1.2.5 Outcomes and Endorsements

To ensure continuous and coherent development of the ATM automation systems harmonized with adjacent regions to enhance systems interoperability, and to keep abreast of the latest developments in ASBU and ATM automation systems, topics pertaining to ATMAS have been focusing and discussing in APAC Region since 2018.

The ICAO Asia Pacific Regional ATMAS Symposium (APAC RATMS) held in Nanjing, China, from 22 to 23 November 2018 successfully addressed Action Item 54/13 of 54th DGCA Conference on ATMAS where it also suggested for States/Administrations to consider establishment of a regional working group/task force under the ICAO CNS Sub-group of APANPIRG to deal with matters arisen from this symposium concerning ATM automation systems. The symposium agreed to formulate an action item for the 23rd meeting of CNS Sub-group in 2019 to review and consider whether such regional working group/task force is needed.

The SURICG/4 was held in Nanjing, China from 9 to 12 April 2019. The meeting reviewed and further discussed the outcomes of the ICAO APAC Regional ATMAS Symposium (APAC RATMS) and other SURICG/4 papers relevant to ATMAS, and endorsed the draft Decision of **“Draft Decision SURICG/4/5-Establishment of ATM Automation System Working Group (ATMAS/WG)”** for consideration by CNS SG.

The Twenty Third Meeting of the Communications, Navigation and Surveillance Sub-group (CNS SG/23) of Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) held at the ICAO Regional Office, Bangkok, Thailand, from 2 to 6 September 2019 considered the report of SURICG/4 with some other CNS SG/23 working papers and noted that a briefing on the proposal on establishing a working group to deal with ATMAS issue was also provided to ATM SG/7 meeting. Several States/Administrations expressed their willingness to support the work of the Task Force, including China, Hong Kong China, India, Indonesia, Nepal, Singapore, Thailand, and the USA. Hence, the meeting adopted the **“Decision CNS SG/23/13 (SURICG/4/5) - Establishment of ATM Automation System Task Force (ATMAS/TF)”**.

APANPIRG/30 meeting that was held from 4-6 November 2019 at ICAO APAC Office, Bangkok, Thailand. The APANPIRG/30 meeting noted with appreciation the work done and achievements by the CNS SG and the contributory bodies reporting to APANPIRG through the SG pertaining to ATMAS. The panel noted that CNS SG/23 meeting had adopted 9 Conclusions and 4 Decisions on technical and operational matters, including the **“Decision CNS SG/23/13 (SURICG/4/5) Establishment of the Asia/Pacific ATM Automation System Task Force (ATMAS/TF)”**.

1.3 Arrangement of ATMAS IGD

This ATMAS IGD consists of the following parts:

Section 1	Introduction
Section 2	Reference Documents
Section 3	System Functional Baseline
Section 4	System Design
Section 5	System Transition
Section 6	System Maintenance

1.4 Document History and Management

The framework of this document was first introduced in the first Working Group Meeting of ATMAS Task Force (ATMAS TF/1) video conference, which was held in October 2020. The Meeting agreed to further develop based on the proposed framework into a complete document for approval as a regional guidance document. A working team consisting of volunteers from China, Hong Kong-China, India, Japan, Malaysia, Philippines, Singapore, Thailand, and Vietnam was established during the Meeting to contribute to document's content. In August 2021, the completed draft of this document was ready for circulation among States for review and comment.

This document aims to supplement SARPs, PANS and relevant provisions contained in ICAO documentation, and it will be regularly updated to reflect evolving conditions. To support the ICAO in making specific recommendations and developing guidance materials, such as minimum functional/performance requirements and additional/local requirements, which aim at facilitating the implementation or provision of robust, safe, efficient, and orderly ATM services by the use of existing and/or new procedures, facilities, and technologies concerning ATMAS.

1.5 Copies

Paper copies of this ATMAS IGD are not distributed. Controlled and endorsed copies can be found at the following website: <http://www.icao.int/APAC/Pages/edocs.aspx>.

Copy may be freely downloaded from the website or by sending an email of request to APANPIRG through the ICAO Asia and Pacific Regional Office.

1.6 Changes to ATMAS IGD

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (refer to Appendix A) should be completed and submitted to the ICAO Asia and Pacific Regional Office. This form may be photocopied as required, emailed, faxed, or emailed to ICAO Asia and Pacific Regional Office +66 (2) 537-8199 or APAC@icao.int. The Regional Office will collate RFCs for consideration by the ICAO Communications, Navigation, Surveillance (CNS) Sub-group of APANPIRG.

When an amendment has been agreed by a meeting of the ICAO CNS Sub-group of PANPIRG, then a new version of the ATMAS IGD will be prepared, with the changes marked by an “[” in the margin, and an endnote indicating the relevant RFC for the traceability of the change. If the change is in a table cell, the outside edges of the table will be highlighted, for example, as follows.

Final approval for publication of an amendment to the ATMAS IGD will be the responsibility of APANPIRG.

1.7 Editing Conventions

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2. REFERENCE DOCUMENTS

Id	Name of the document	Edition	Date	Origin	Domain
1	Annex 2 - Rules of the Air	10th Edition	2005	ICAO	
2	Annex 12 - Search and Rescue	8th Edition,	July 2004	ICAO	
3	Annex 11 — Air Traffic Services	15th Edition	2018	ICAO	
4	Annex 17 - Security	10th Edition	2017	ICAO	
	11th Edition	March 2020	ICAO		
5	“PANS-ATM, or Procedures for Navigation Services – Air Traffic Management (DOC 4444)	16th Edition (Amendment 9 dated 5/11/20)	2020	ICAO	
6	Global Air Navigation Plan (GANP) (Doc 9750)	6th Edition	2020	ICAO	
7	Global Air Traffic Management Operational Concept (Doc 9854)	First Edition	2005	ICAO	
8	Manual on Air Traffic Management System Requirements (Doc 9882)	First Edition	2008	ICAO	
9	Manual on Global Performance of the Air Navigation System (ICAO Doc 9883)	First edition	2009	ICAO	
10	Doc 10031 Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes	First edition	2014	ICAO	
11	Restricted—Air Traffic Management Security Manual(Doc 9985)	First edition	2013	ICAO	
12	Air Traffic Services Planning Manual (Doc 9426)	4th Edition	2007	ICAO	
13	Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive (Doc 9574)	4th Edition	2013	ICAO	

Air Traffic Management Automation System

Implementation and Guidance Document

14	Performance Based Navigation (PBN) Manual (Doc 9613)	4th Edition,	2013	ICAO	
15	Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)	2nd Edition	2007	ICAO	
16	Manual of Air Traffic Services Data Link Applications (Doc 9694)	5th Edition	2010	ICAO	
17	Manual on Flight and Flow — Information for a Collaborative Environment (FF-ICE) (Doc 9965)	First edition	2012	ICAO	
18	Manual on Simultaneous Operations or Parallel or Near-Parallel Instrument Runways (SOIR) (Doc 9643)	2nd Edition	2020	ICAO	
19	Pan Regional (NAT and APAC) Interface Control Document (ICD) for ATS Interfacility Data Communications (PAN AIDC AIDC)	Version 1.0	2014	ICAO PAN	
20	ICAO Asia/Pacific Regional ADS-B Implementation and Operations Guidance Document (AIGD)	Version 13.0	April 2021	ICAO APAC	
21	ICAO Asia/Pacific Regional Mode S DAPs Implementation and Operation Guidance Document	Edition 3.0	2021	ICAO APAC	

3. SYSTEM FUNCTIONAL BASELINE

The functional baseline, forming the core of the ATMAS, is broadly described as those involved with the processing and display of operational information that will be used in providing an alerting, flight information, and separation service to aircraft.

3.1 System Essential Functions

In order to provide controllers with the display of air situation, the ATMAS is suggested with the following essential functions.

- a. Surveillance Data Processing Function (SDP). Chapter 3.1.1 introduces the essential surveillance data processing function. For the processing of enhanced surveillance data such as ADS-B, please refer to chapter 3.2.1.
- b. Flight Data Processing Function.
- c. Bypass Surveillance Data Processing Function.
- d. Correlation of Surveillance and Flight Data function. Chapter 3.1.4 introduces the essential correlation function with mode 3/A code. The processing of using 24-bit address code etc., as the condition for correlation, please refer to chapter 3.2.2.
- e. Safety Net Function. Chapter 3.1.5 introduces the essential Safety Net function. For the extended Safety Net function, such as Medium Term Conflict Detection Warning (MTCD), please refer to chapter 3.2.3.
- f. Meteorological Information Processing Function.
- g. Air-Ground Data Link Function (AGDL).
- h. Variable System Parameter (VSP) Management Function.
- i. ATS Inter-facility Data Communication Function.
- j. Human Machine Interface Function (HMI).
- k. Recording and Playback Function. Chapter 3.1.11 introduces the essential data recording and playback function. For the video recording and playback function, please refer to chapter 3.2.7.
- l. System Monitoring and Controlling Function.
- m. Software Version Management Function.
- n. GNSS Time Synchronization.

3.1.1 Surveillance Data Processing Function

SDP is one core function of ATMAS. SDP should be able to integrate multiple radars and process the received data to generate a unique system track. System tracks contain accurate real-time positioning information, which correlates with flight plans and is displayed on HMI with specific track symbols.

Usually, SDP includes the following functions:

- a. Access and process data from primary radar, secondary radar, primary and secondary combined radar, and weather data from PSR radars.
- b. Pre-process the surveillance data to monitor the data quality.
- c. Process mono-sensor surveillance data and generate mono-sensor track.
- d. Process multi-sensor surveillance data and generate continuous and smooth system tracks adopting advanced tracking filtering algorithms.
- e. Manage the altitude tracking and perform conversion of Mode C derived data according to QNH value.
- f. Provide prompts in case of overload, filter received data, and discard extra data.
- g. Process the special position identification pulse (SPI) and display using a unique indication.
- h. Allow special area definition to improve system track accuracy.

3.1.1.1 Surveillance Data Pre-processing

The system is recommended to process standard radar formats, including ASTERIX format and related standards. It should automatically identify the form of surveillance data, then decompose and extract the data items according to the corresponding format specifications.

The system is encouraged to be able to monitor the received data quality and filter out the abnormal data to ensure the data fusion quality. The surveillance data quality check is suggested by considering the following factors:

- a. CRC error.
- b. Data frame error.
- c. North messages lost.
- d. Radar sector crossing messages lost.
- e. Track lost.
- f. Timestamp check.

3.1.1.2 Mono-radar Data Processing

The system is recommended to perform syntactic and semantic checks on the received data against specifications, including the target attributes, identifier (SSR code, track number, address code, etc.), position, altitude, speed, time stamp, SIC/SAC, etc.

The system is suggested with time drift management to handle abnormal time stamping, and correct the timestamp by adding a time shift in received data.

The system handles target correlation for the purpose of generating a new track, or updating the existing, or deleting the dated, and then form a stable mono-radar track in the end.

3.1.1.3 Multi-radar Data Processing

The system fuses the accessed multi-radar to generate a stable system track by associating the targets of multiple radars, and forms a unique target identification mark. When the radar data are associated, the data and state attributes of radar, including position, secondary code, altitude, speed, track characteristics, and other data, are considered.

The system associates the existing system track for updating or establishes a new track to ensure accuracy, continuity, and smoothing. Abnormal data derived from some radars should not impact system track quality. The system track is provided to alert calculation, correlation process, and HMI display. In the track fusion process, the system records the quality of every surveillance sensor to estimate the quality of this sensor based on historical and real-time data. Abnormal data derived from some radars should not impact system track quality.

3.1.1.4 Target Altitude Tracking and Processing

The system is suggested to provide altitude tracking by extrapolating the flight level according to the current mode C value and altitude change rate.

The system should support QNH area definition and correct Mode C values into barometric altitudes for all aircraft in a specific QNH area.

The system should discard abnormal altitude reported.

3.1.1.5 Special Pulse Identification Processing

When receiving SPI from radar track, the system is suggested to display a prompt on track identifier automatically.

3.1.1.6 Automatic Test Target Monitoring

The system is advised to be capable of monitoring the quality of radar via automatic Test Target Monitoring with fixed SSR Test Transponders.

3.1.1.7 Surveillance Data Overload Processing

The system should detect plots overload (i.e., the maximum number of plots per radar and per antenna revolution and the maximum number of plots per radar and per sector) to filter out excess plots.

The system is recommended to cope with surveillance data overloading processing as follows:

- a. When the total number of targets processed by SDP reaches a certain threshold, the system will automatically generate a warning prompt.
- b. When the total number of targets exceeds the load threshold, the system will give prompts to users and considers filtering or discarding the extra data.

3.1.1.8 Special Area Setting and Processing

The system is proposed to be capable of:

- a. Defining areas of interest (AOI) for each sensor and discarding reports outside the AOIs.
- b. Defining inhibition areas for each sensor and stopping track initialization but provide reports for exist track in the inhibition areas.
- c. Defining distrust areas for each sensor, and discard reports in the areas.

3.1.1.9 Real-time Quality Control (RTQC) of Radar

Real-time quality control (RTQC) is used to monitor and control the quality of radar signals received by the system. It calculates the radar (sensor) correction factor and the fusion weight coefficient based on the results of monitoring and controlling. RTQC should manually and automatically compensate for the deviation in azimuth and distance of radars or sensors to improve the radar detection accuracy and provide the necessary fusion parameters for subsequent multi-radar tracking processing.

When the RTQC finds abnormal monitoring data, it gives a warning on the system monitor interface in real-time. When the quality of one or more data sources is abnormal or interrupted, the system will isolate it to ensure the system tracks in a normal work state. The system judges the availability of the data according to the confidence coefficient of source surveillance data.

3.1.1.10 System Tracks Output

- d. The system should output the system tracks according to various specified radar formats (such as ASTERIXcat062, etc.).
- e. The output system tracks can be adjusted within a reasonable range by modifying parameters, and its fastest update rate is the same as the track of ATMAS.

3.1.2 Flight Data Processing Function

Flight data processing (FDP) is one core function of the ATMAS. Data relevant to flight plan are received, stored, processed, and updated by FDP. FDP can also exchange data with other software modules.

Usually, FDP includes the following functions:

- a. ATS messages processing, which processes ICAO, AIDC, OLDI, and other format messages.
- b. Flight plan life cycle management to the flight plan.
- c. 4D profile trajectory computation, including route analysis, profile calculation and time estimation, SID /STAR /runway automatic allocation.
- d. SSR code management, including SSR code automatic assignment and manual SSR codes assignment by controllers;
- e. Sector management and posting computation, post flight plans based on conditions, and provide electronic postings and paper flight strip printing at the designated position;
- f. Flight plan data exchange with other external systems (such as Main/Fallback ATM automation systems, tower ATM automation systems, air traffic flow management systems, etc.). This part will be described in detail in section 5.7 of this document.

3.1.2.1 Flight Message Processing

The system should be capable of processing flight messages following ICAO PANS-ATM(Doc 4444) and AIDC and other related regulations, including FPL, CHG, CNL, DEP, ARR, DLA, CPL, EST, CDN, ACP, LAM.

The system is advised to perform semantic and syntactic checks on the received messages and create or update associated flight plans with correction. Messages that failed in semantic or syntactic checks are categorized and sent to the designated position for manual processing. Manually corrected messages will be processed again by the system.

The system is suggested to be designed with a messages manual transmission function and provide a default template for each type of message to be modified and confirmed by users.

The system is recommended to transmit messages according to the pre-defined conditions and addresses automatically. At least the following types can be sent: FPL, DEP, ARR, CHG, DLA, CPL.

3.1.2.2 Life Cycle Management

The system shall be able to manage the life cycle of flight plans. Flight plan states could be generally defined as INACTIVE, PREACTIVE, COORDINATED, ACTIVE, FINISHED, etc. Users can adjust the above states according to the operation requirement.

The evolution of the flight plan states could be triggered automatically based on time, message, correlation, etc., or by manual input.

Examples of the central state transition conditions and processing are as follows:

a. **INACTIVE**

When created, the flight plan state is INACTIVE.

Typically, all flight plans in INACTIVE state support manual modification or via ATS messages.

b. **PREACTIVE**

When the flight is approaching its execution and control airspace, the flight plan state will change to PREACTIVE.

At PREACTIVE state, the system is suggested to perform 4D trajectory and posting computation and send flight strips to relevant positions. The system could allocate SSR codes, departure runways, and SIDs for departure flights.

c. **COORDINATED**

When the flight is ready for control, the plan state will change to COORDINATED which can be triggered by manual operations or system events.

The flight plan in the COORDINATED state is qualified for correlation with system tracks.

d. **ACTIVE**

The flight plan state becomes ACTIVE when the flight is in the jurisdiction. Generally, the system calculates and updates 4D trajectory based on surveillance data, air-ground data, and manual commands. The flight plan in the ACTIVE state is qualified for correlation with system tracks.

e. **FINISHED**

When the flight plan is no longer used to assist in controlling the actual flight, the plan state becomes FINISHED.

At the FINISHED state, the system is suggested to:

- Release the SSR code.
- Stop the 4D trajectory calculation.
- Delete posting events and remove the electronic flight strip.
- Save the records for further analysis and statistics.

f. Other states

In addition to the above states, users can also define SUSPENDED, INHIBITED, and other states according to operation requirements. Under these states, FDP will stop updating the flight profile and suppress related alarms.

3.1.2.3 4D Profile Trajectory Calculation

It is recommended the system support 4D flight profile trajectory calculation. The profile calculation is continuous and generally divided into three stages: climb, level flight, and descent. The profile may start from the departure airport or the fixes before the FDRG entry, containing height and time information for each waypoint, and ends at the destination airport.

The profile calculation could refer to waypoint information, DEP/ARR airport, runway, requested altitude, cruise speed, aircraft performance parameter, GRIB, target position, real-time data input by controllers, etc.

The profile updates could be done at the change of flight attitude, passing waypoints, sector boundary points, system events, or controller inputs.

The system is proposed to automatically allocate departure runways and SIDs for departure flight plans and arrival runways and STARs for arrival flight plans. The system would provide the function of manual assignment, modification, and deletion to SID/STAR/runway.

3.1.2.4 SSR Code Management

Usually, the system is capable of manually and automatically assigning SSR codes.

The system is recommended to adopt specific SSR code group and allocation rules according to the type of flights (inbound and outbound).

The system is suggested to perform an SSR code retention check and use the SSR code in received messages (e.g., DEP messages) if the code is available. If not accessible, the system will allocate a new code from the free code list. In case of no free codes, the system could assign an SSR code from the given code list, and the earliest allocated code should have priority.

Generally, the system is not supporting special codes (such as 7700, 7600, 7500, etc.) assignment.

The SSR code will be released when the flight plan is finished.

The system is proposed to support manually modifying the flight plans' SSR. If the input code is already occupied, a prompt is suggested to be produced.

It is recommended that the system uses A1000 as Mode S conspicuity code. The flight plan with that code will use a 24-bit address or ACID to correlate with system tracks, and warnings/alerts should not be generated when SSR duplication occurs due to Mode S conspicuity code.

3.1.2.5 Sector Management and Posting Computation

Normally, the system can pre-configure the airspace into different sectors and enables the controllers to group or ungroup these sectors online.

The system is recommended to post the relevant electronic flight strip to the designated sector according to offline defined conditions. The electronic flight strip is suggested to display on the controlling sector and posted sector in specific colors.

The system is proposed to compute and insert posting events based on the waypoints or sectors in the flight plan. Posting conditions are tightly linked with the operational concept and control procedures, including waypoints, altitude range, ACID, airport, runway, flight rule, flight type, etc.

The system is advised to support the manual and automatic transfer of jurisdiction. The automatic transfer could be computed based on offline rules to get the timing and the target sector. The mechanical transfer conditions are similar to posting conditions.

3.1.3 Bypass Surveillance Data Processing Function

To further enhance resilience, bypass surveillance data processing (BSDP) could be implemented according to the operational need. BSDP is a redundancy module of SDP, which can independently receive, process and distribute surveillance data independently to SDP. When the SDPs fail, the system will switch to BSDP automatically. When the system switches to bypass mode, the HMI should clearly indicate if controller is working in BSDP mode.

BSDP is recommended to be capable of directly accessing various surveillance sources, using a different tracking algorithm with SDP.

BSDP should at least provide mono-sensor tracking function. Multiple-sensor data tracking function and alarm functions, such as Special Codes alert, Short Term Conflict Alert (STCA), Minimum Safe Altitude Warning (MSAW), Area Proximity Warning (APW), etc., could be considered as part of BSDP.

3.1.4 Correlation of Surveillance and Flight Data

The objective of the surveillance and flight plan correlation function is to establish an association between a surveillance track and a flight plan based on identifying codes and position checks. The way to develop association includes automatic and manual correlation.

3.1.4.1 Automatic correlation

Usually, the system performs an automatic correlation between the flight plan and the system track when pre-defined conditions are met, for example:

- a. Specific flight plan status.
- b. Identical SSR code.
- c. Passing position and altitude check.

The flight plan in the system has two kinds of SSR codes:

- a. ASSR (Assigned SSR code): currently assigned to the flight plan within the FIR.
- b. PSSR (Previous SSR code): used for inbound flight, which was used in the previous FIR or the previous code used in the case of a code change within the FIR.

The position and altitude checks will improve the accuracy of correlation. The method of position and altitude checks are suggested as follows:

- a. Whether the track position is in the route model. The route model is composed of airports, waypoints, and route corridors in the flight plan.
- b. Whether the difference between the estimated flight plan position and the track position is within a certain range.
- c. For take-off and landing system tracks, the altitude check is recommended to be performed.

3.1.4.2 Manual Correlation

The system is recommended to support manual correlation of a flight plan with a track by controllers, for example, using mode 3/A code as a criterion.

A warning message is suggested to be provided if the manual correlation is failed.

3.1.4.3 Cancel Correlation

The system is suggested to cancel correlation if the correlation conditions are no longer met, and automatically generate a warning prompt to designated position except Emergency Settings.

Under emergency settings, the system is advised to maintain the correlation when the SSR code is changed to 7500, 7600, and 7700.

3.1.4.4 Correlation Data Distribution

After correlation, the system is recommended to distribute correlation information to other modules and display correlated system tracks on the controller positions.

Usually, the system updates the flight profile according to the position and altitude information of the correlated surveillance track.

3.1.5 Safety Net Function

Safety Net Function serves to alert controllers of a potential, imminent or actual infringement of safety margins to prevent hazardous situations from developing into major incidents or even accidents. The aviation safety areas covered by Safety Net Function generally include:

- a. Aircraft Separation.
- b. Airspace Operation Requirement.
- c. Conformance of Clearance.
- d. Terrain Clearance.
- e. Approach/Departure Path Conformance.

Alerts/warnings from Safety Net Function are generated based on different levels of severity of infringement and imminency with distinguishable visual and/or aural alarms with their prominence corresponding to the severity and imminency of the infringement.

During the planning stage, States/Administrations are encouraged to conduct a comprehensive study on the applicability of safety net features in ATMAS to their local environment considering system behavior, Human Machine Interface (HMI) design, and operational procedures. By design, the Safety Net Function in the ATMAS should be configurable with various parameters on activation/deactivation/acknowledgement of alarm adjustable by the users. Where applicable, references, especially on test strategy and system parameters, to successful cases of Safety Net implementation by other States/Administrations are suggested.

For actual implementation of Safety Net Function, a progressive approach is suggested with potential advantages as below:

- a. Reducing risks in implementation and operation of one safety feature at a time as compared to deployment of all planned safety features in one go;
- b. Reducing demand for resources and staff workload involved in the evaluation of the safety features; and
- c. More time for air traffic controllers to evaluate the safety features and fine-tune the parameters before further implementation.

A post-implementation review is recommended, including the collection of feedback and suggestions from frontline air traffic controllers, effectiveness and performance of the safety features (such as user-friendliness, alert timeliness, nuisance alerts), data analysis to gauge improvement in safety figures with a view to continuously fine-tuning of safety net parameters to reduce nuisance alerts.

3.1.5.1 Types and Priority

The system provides safety net to controllers with visual and aural indications, integrating surveillance data, flight plan data, and other operational data using different algorithms and rules.

The safety net includes Emergency, STCA, MSAW, APW, APMW, etc.

It is recommended that the system is capable of setting the priority of alerts. The priority of warning is higher than its corresponding pre-warning. The emergency should have the highest priority, including Hijack (7500), Radio Failure (7600), Emergency (7700), etc.

3.1.5.2 Emergency

Once the Emergency codes were received, the system is suggested to process it and display the Emergency on the concerned positions.

The emergency codes include:

- a. 7500 (Hijack).
- b. 7600 (Radio Failure).
- c. 7700 (Emergency).

Normally, the Emergency is displayed until the received Mode 3/A code is different from the emergency code.

3.1.5.3 Short Term Conflict Alert

Short Term Conflict Alert (STCA) is an important safety net feature of ATMAS as collision avoidance tool, or to provide a separation alert for a potential or actual infringement of separation minima between aircraft. STCA can work between targets associated with an FPL and unknown targets without an FPL.

The STCA function in ATMAS generates visual and/or aural alerts to controllers in air situation display if any aircraft is predicted to or is violating a pre-defined conflict or separation minimum in the STCA settings of the ATMAS. Controllers would need to resolve the conflict immediately once the alert has been generated.

Surveillance, flight plan, and environmental data are required for generating STCA in ATMAS. The following list of information could be considered to include in the STCA processing:

- a. Aircraft position

- b. Pressure altitude
- c. Cleared flight level
- d. Flight rule
- e. RVSM status
- f. Concerned controller jurisdiction
- g. Separation standards of STCA areas
- h. Look-ahead time

The Flight plan is not obligatory. Flight plan data, i.e., cleared flight level, flight rule, and RVSM status of the aircraft, could help improve the relevancy of alert generation so as to reduce cases of nuisance alerts. In addition, the implementation of STCA inhibition could be considered based on a definition of inhibition zones, SSR code groups, callsign, or other conditions applicable to the local operating environment and needs.

The STCA processing cycle is recommended to be at a frequency not less than once per track update of ATMAS. States/Administrations could also consider implementing STCA with two stages of alerts based on the situation of predicted and actual infringements, i.e., Predicted Conflict Alert (PCA) and Conflict Alert (CA).

For complex airspaces with different separation standards for respective sectors, the design of ATMAS is recommended to allow the configuration of multiple STCA volumes. Users could apply specific STCA parameters for a given STCA volume according to operational needs.

The performance of STCA is highly dependent on the optimization of the conflict detection algorithm and adapted parameters for the local environment. States/Administrations are suggested to work closely with system manufacturers to adapt the STCA detection according to the local environment. For successful implementation, regular review with controllers on the performance is necessary.

3.1.5.4 Minimum Safe Altitude Warning

Minimum Safe Altitude Warning (MSAW) is intended to assist controllers with alerts of the potential risk of an aircraft infringing a defined minimum safe altitude over a concerned region.

The MSAW function monitors the position and altitude of an aircraft against defined MSAW regions and minimum safe altitudes. The MSAW region can be defined by height or polygon. When the altitude of an aircraft is found or predicted to be lower than the applicable minimum safe altitude within defined the MSAW region, a visual and/or aural warning would be generated to alert controllers to take necessary actions to resolve the infringement.

For reference, examples of surveillance, flight plan, and environmental data are required for the MSAW functional module to generate alerts are:

- a. Aircraft position.
- b. Pressure altitude.
- c. Cleared flight level.
- d. Flight rule.
- e. Concerned controller jurisdiction.
- f. Terrain and obstacle model.
- g. Look-ahead time.

To minimize nuisance alerts, flight rules and cleared flight levels in flight plan data can help improve the relevancy of MSAW alert generation. In addition, States/Administrations could consider implementing MSAW alert inhibition which suppresses MSAW alerts based on defined inhibition zones (such as final approach zones), SSR code groups, callsign, or other conditions applicable to the local operational environment.

The accuracy of MSAW alert is related to MSAW terrain/obstacle definition, look-ahead time setting, and inhibition strategy adopted for flights intentionally flying close to terrains/obstacles. Appropriate settings of the above are necessary for providing a reliable MSAW detection that controllers can rely on. Any unoptimized parameters would likely result in nuisance alerts or insufficient time for controllers to respond to the alert. It is important to perform tuning of MSAW parameters based on controllers' feedback for successful MSAW implementation.

3.1.5.5 Area Proximity Warning

Area Proximity Warning (APW) is a safety net for alerting controllers of any potential or actual unauthorized penetration of aircraft into Special Use Airspaces (SUA) including:

- a. Danger airspace.
- b. Prohibited airspace.
- c. Restricted airspace.
- d. Temporarily restricted airspace.

Each SUA volume could be defined in ATMAS as an area (e.g., circle, polygon, etc.) with upper and lower bounds on altitudes. The warning activation/deactivation of each SUA could be triggered automatically according to an online-defined schedule or by the manual action of controllers. The system should provide APW inhibition function based on flight rules, SSR code groups, callsign, and other conditions applicable to the local environment and operational needs.

3.1.5.6 Approach Path Monitoring Warning

The Approach Path Monitoring Warning (APMW) monitors the aircraft's vertical and lateral deviation from the final approach profile in ATMAS, and generates visual and/or aural alerts when an aircraft exceeds or is predicted to exceed the defined tolerance of deviation. The system should allow multiple groups of glide path monitoring parameters to be defined.

An APM zone would generally be defined in ATMAS for performing APMW processing on flights. Examples of parameters on the definition of APM zone are:

- a. Runway name and direction.
- b. Touchdown point on the runway.
- c. Horizontal angular extend from the touchdown point.
- d. Vertical angular extend from the touchdown point.
- e. Distance from the touchdown point.
- f. Glide slope elevation.
- g. APMW inhibition zone.

Surveillance, flight plan, and environmental data are required for generating APMW. The APMW prompt will be given on the HMI when the alarm conditions are met.

To minimize nuisance alerts, checking flight rules could help improve the relevancy of warning generation. In addition, an aircraft flying close to terrains/obstacles during the final approach which could easily trigger MSAW alert due to nearby terrains/obstacles. States/Administrations could consider suppressing MSAW alert generation in ATMAS within the APM zone or via the definition of inhibition zones if an aircraft's descent profile is already under the monitoring by APMW.

The performance of APMW is highly related to adapted APMW parameters for the local environment, look-ahead time setting and inhibition strategy adopted for flights that intentionally deviated from the optimal final approach path. Regular review of the performance is crucial for the tuning of APMW parameters based on controllers' feedback to increase its effectiveness.

3.1.6 Meteorological Information Processing Function

Generally, the system is capable of receiving, processing, and displaying meteorological information, including GRIB, QNH, and weather data derived from mono-radar. The meteorological information should be applied in surveillance data and flight data processing.

The system could process GRIB messages from the meteorological information system, which contains upper wind and temperature for accurate calculation and estimation of flight plan profiles.

The system is recommended to automatically extract and process QNH data from METAR and SPECI messages, as well as manual input.

The system is recommended to be capable of receiving and processing mono-radar derived weather data, and displaying it on the controller positions. From experience, the categorization of weather echo display could be classified as no less than three levels. The parameters of display level and priority could be defined as required.

3.1.7 Air-Ground Data Link Function

The AGDL function mainly processes the information based on the data link communication, including ADS-C (Automatic Dependent Surveillance-Contract), CPDLC (Controller-Pilot Data Link Communication), and DCL (Departure Clearance), etc. States/Administrations could implement the Air-Ground Data Link Function according to the operational needs.

3.1.7.1 ADS-C Data Processing

The ADS-C data processing is recommended as follows:

- a. The system automatically determines whether the aircraft enters the ADS-C area according to route information.
- b. The ADS-C connection could be initiated by pilots or controllers.
- c. The system receives and processes ADS-C messages, including periodic contract, event contract, emergency, current location, etc.
- d. The system updates and manages ADS-C tracks with received ADS-C messages.

3.1.7.2 CPDLC Data Processing

From experience, the system is suggested to provide the following functions for CPDLC data processing:

- a. Display CPDLC position report and flight data.
- b. Display a CPDLC dialogue window.
- c. Determine whether the aircraft enters the CPDLC area according to route information.
- d. Allow initiating a CPDLC connection automatically or manually by the pilot or the controller.
- e. Receive and process CPDLC downlink messages, send CPDLC uplink messages, and manage the message status.
- f. Allow to search CPDLC historical messages and display the messages in chronological order.

- g. Provide prompts to controllers in the following cases: correct message transmission and reception, manual operation, and successful logon.

3.1.7.3 DCL Processing

The system is recommended to provide the following DCL functions:

- a. Receive, process, and send DCL messages (ARINC 623, EUROCAE ED-85A, etc.).
- b. Identify and process the RCD message and automatically send error messages to controllers suggesting voice-clearance in case of invalid RCD message.
- c. Correlate the RCD message with a specific flight plan according to the callsign, departure airport, landing airport, and automatically reply with an FSM message.
- d. Automatically send CLD messages according to the correlated FDR and manual input data and perform synthetic and semantic checks.
- e. Check the compliance between the CDA and CLD message.
- f. Be capable of displaying RCD information, including the callsign, SSR code, CLD processing identification, and enable the edition and transmission of CLD messages.

3.1.8 System Parameter Management Function

For the convenience of system maintenance, the system is proposed to be capable of managing the variable system parameters through a user/ops orientated adaptation interface used by trained adaptors.

3.1.8.1 Types of System Parameters

The system is recommended to be able to adapt system functional parameters for all functionality.

That parameters adaptation is highly preferential to software-code based system management, e.g., pre-set files.

Those parameters are designed to accommodate future performance loads to avoid errors or limitations brought on by inflexible value limits.

That parameters adaptation is orientated towards use by ATS operational orientated staff. Variables, their units of use, and values range should reflect the operational application.

Generally, the types of system parameters include the following:

- a. Basic parameters: airspace, sectors, positions, routes, QNH areas, etc.

- b. Surveillance data parameters: surveillance source parameters, fusion parameters, etc.
- c. Flight data parameters: message processing and transmission rules, SSR code allocation rules, FDR parameters, etc.
- d. System interface parameters: interface configuration parameters.
- e. HMI parameters: sectorization parameters, electronic and paper flight strips formats, CFL popup values, system maps, etc.
- f. Alert parameters: warning and inhibition area definition, warning condition parameters, etc.
- g. Other maintenance parameters: recording parameters, warning messages, error messages, etc.

3.1.8.2 System Parameter Management

The system is recommended to support a graphical user interface tool, such as Database Management System (DBMS) to establish, delete, modify, display release, and validate the online/offline system parameters.

The DBMS tool is suggested to support accuracy check, provide error prompts and references according to parameters format, character length, and mold to ensure accuracy of parameters, and limit illegal input of the parameters. The system has the fallback function. If a step of parameters setting goes wrong, you can go back to the previous step.

3.1.8.3 System Parameter Activation

In order to balance the efficiency and safety, by experience, the system is suggested to support the following two ways to let the system parameters go into effect:

- a. Online generate: for parameters allowed to be configured, selected, and generated online, without restarting the system.
- b. Offline generate: for parameters to be generated after restarting the entire system or specific system modules.

3.1.9 ATS Inter-facility Data Communication Function

The system is recommended to incorporate an AIDC application that supports the ATS-related information exchanges within the ATMAS of adjacent Control Units and Flight Information Regions adopted in the Asia-Pacific region.

The AIDC function of the system should conform to the standards in the prevailing version of the following documents:

- a. Pan Regional (NAT and APAC) PAN AIDC ICD; and

-
- b. Procedure for Air Navigation Services-Air Traffic Management (PANS-ATM) (ICAO Doc4444).

3.1.9.1 AIDC message transmission and processing

The system should support the core AIDC messages recommended in Asia/Pacific Regional ICD, such as ABI, CPL, EST, MAC, CDN, ACP, REJ, TOC, AOC, EMG, MIS, LAM, and LRM.

The system should be configurable in supporting variations in AIDC processing and messages dependent on the mutual agreements with each adjacent Control Unit or FIR.

Commonly, the system is recommended to transmit AIDC messages automatically, and be capable of processing received AIDC messages automatically.

The system is suggested to transmit ABI, EST, PAC, and other messages automatically according to the AIDC handover conditions and the status of the flight plan.

The system is proposed to transmit TOC and EST messages manually through the HMI in specific cases. The flight data operation position (FDOP) is capable of processing erroneous and irrelevant messages manually.

For received messages that failed syntactic and semantic checks, the system should send such messages to a message queue to process by controllers manually.

The system is expected to alert controllers of any unsuccessful transmission of AIDC messages due to communication fault, rejection by the receiving adjacent Control Units or FIRs, or failure to receive an expected application response from the receiving Control Unit within a time threshold.

3.1.9.2 AIDC Handover

The system should be able to trigger AIDC handover automatically, depending on configured AIDC handover parameters, which may include handover points, height, time, adjacent Control Unit, etc.

The system could allow controllers to initiate AIDC handover manually.

3.1.9.3 AIDC Coordination Process

Generally, the AIDC handover is mainly fulfilled by exchanging a variety of messages. The AIDC procedure is composed of three phases forming a standard AIDC process:

- a. Notification Phase;
- b. Coordination Phase; and
- c. Transfer of Control Phase.

The standard AIDC procedure could be simplified according to the handover agreement between adjacent Control Units. For example, taking advantage of several indispensable messages regarding EST/PAC, ACP, TOC, AOC, and LAM, the handover could be simplified into two phases coordination and handover. The procedure is shown in the figure below:

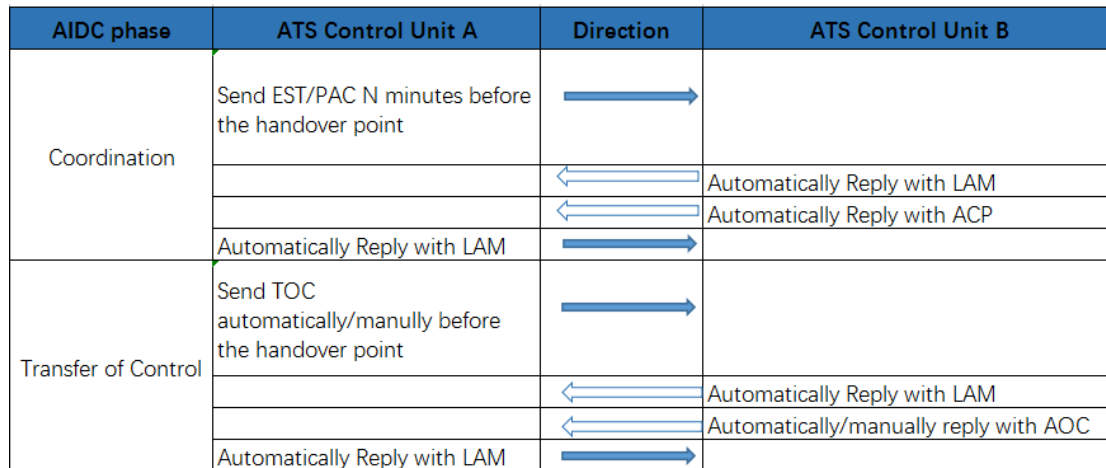


Figure 3.1.9-1 Simplified AIDC procedure

The system could update the flight state of a flight as it transits through the AIDC coordination phases.

After completing a coordination process, the system could automatically update the concerned flight plan with the cleared flight profile.

The system is expected to alert controllers when coordination with an adjacent Control Unit or FIR is not completed within certain time thresholds before Estimated Time over Boundary RP, Estimated Time of Departure, etc.

3.1.10 Human Machine Interface Function

HMI (Human Machine Interface), as an important part of the ATMAS, is the medium for interaction and information exchange between the system and controllers. Operational users can monitor air traffic situations and modify flight plans and other relevant information through physical peripherals and/or onscreen control interfaces. Technicians can monitor the status of the ATMAS and perform technical maintenance operations as well. HMI design of ATMAS should consider the day-to-day operation of air traffic controllers to provide a user-friendly interface for controllers to perform their duties effectively and efficiently. In general, the design should facilitate safe, efficient, and sustainable control of air traffic based on the following principles:

- Accurate presentation of air traffic data
- Timely presentation of air traffic data
- Automatic data validity checking including operator input
- Input options automatically limited to valid data selections

-
- e. Allow a variety of user-friendly input methods (e.g., keyboard, number pads, mouse, etc.) for data entry by controllers

For friendly use,, the HMI function is recommended to include at least as follows:

- a. Providing graphical interfaces and functions for different positions, such as supervisor position, controller position, flight data operator position, etc.
- b. Providing multiple position modes (e.g., Normal, Degraded, Bypass, and Mono) if required.
- c. Providing variable user modes (e.g., Operational, Free, Shadow, and Replay) if required.
- d. Providing a complete set of HMI configuration, including track display, HMI layout, menu setting, color management, mouse/keyboard functional definitions, map management, etc.
- e. Providing the operation interfaces for flight plan modification and control/management of onscreen information.
- f. Providing warnings related to HMI.

3.1.10.1 Controller Position

The controller position provides controllers with relevant information required for air traffic control, helping the controller be fully aware of the situation and manage the aircraft in the responsible area. The specific functions are suggested as follows:

- a. Display system tracks, multi-radar tracks, multi-ADSB tracks (if available), multi-WAM tracks (if available), flight plan tracks, and bypass tracks.
- b. Enable interactive flight operations such as aircraft handover and acceptance, manual correlation, level assignment, and coordination status.
- c. Allow screen operations such as zoom in, zoom out, off-center, measurement, window movement, label rotation, etc.
- d. Manage map display.
- e. Display and edit Flight plans.
- f. Post and display electronic flight strips/flight data list.
- g. Display system information.
- h. Personalize position parameters and display.
- i. Other relevant information required for operations.

3.1.10.2 Supervisor Position

The supervisor position typically has the same display and operation interface as the controller position. In addition, the system is advised to provide other functions on the supervisor position, such as online operation parameters settings and management, SSR code management, sector management, automatic handover setting, position alert management temporary/global map setting, etc.

3.1.10.3 Flight Data Operator Position

The flight data operator position is capable of displaying relevant flight plans in a flight list containing all the flight information fields, and enabling the online flight plan editing function and AFTN message display, query, error correction, and sending function.

3.1.10.4 Technical Management Position

The technical management position provides a graphic interface enabling efficient system maintenance and software management. The specific functions of the position are generally as follows:

- a. Technical parameters management.
- b. Operational parameters management.
- c. Software configuration and management.
- d. User Management.
- e. Map generator.

3.1.10.5 Position Mode Switch

The system could be designed to provide controller positions with various user modes to cater to different operational needs. Below is an example of different user modes.

States/Administrations could define their own set of position modes according to the operational need.

- a. Operational mode

The position in operational mode is allocated with sector and provides ATC service.

- b. Free mode

The position in free mode is sector-free and functionally limited, such as read-only access to flight data.

- c. Shadow mode

The position in shadow mode provides real-time monitoring of the operational position of specific sectors and the functionally limited, such as read-only access to flight data.

d. **Replay mode**

The system only provides playback function in replay mode and cannot be used for ATC service.

3.1.10.6 Track Display

The graphical representation of a track usually includes a track symbol located at the current position of the aircraft, a label, a label leader, a selectable velocity vector, and a selectable number of track history dots, etc.

The system should be able to display the accurate position of the track, generated and updated according to surveillance source.

From experience, the system can customize of the display of information in different layout types to show information on the label in different levels of detail depending on the operational needs.

The system is suggested to support label action such as CFL modification, handover request and acceptance, runway modification, STAR allocation, etc.

3.1.10.7 Map Display

The system is recommended to be capable of the offline definition of the system maps, the online creation of the local maps by individual controller position, and the online creation of the Global Map, temporary Restricted / Danger Area maps, etc. by the supervisor position.

The online created local map, global map, and temporary restricted / danger area maps could be saved and restored automatically during system restart.

Note: Controllers should use the online creation of maps with caution to avoid safety impact.

3.1.10.8 Flight Plan Window

The flight plan window is suggested to support displaying and modifying of the flight plan data fields such as SSR code, ACID, flight rule, aircraft type, wake category, departure airport, destination airport, requested flight level, route, field 18 data.

The flight plan window is recommended to enable at least the following flight plan functions: creation, deletion, modification, flight strip printing, etc.

3.1.10.9 Electronic Flight Strip Function (if applicable)

Electronic Flight Strip Function could be implemented as a part of HMI function, from which controllers can access to do handover, acceptance, filtering, and sorting function. The electronic flight strips can be sorted and displayed by flight plan state, route fixes, time information, etc.

3.1.10.10 System Information Display

It is recommended to provide in the HMI system information, including device failure, operational data, feedback of operation, system status information, etc., for controllers' awareness of system status.

3.1.10.11 Tracks Quick Search

It is recommended that the system has a quick search function to search a track with complete or partial search criteria of the callsign, SSR code, departure/destination airport, or other information. The matching track will be highlighted to the controllers.

3.1.10.12 Track/Label Filtering

It is recommended that the system provides a track and/or label filtering function.

The system could filter tracks based on upper/lower limitation of level or SSR code, and search the track label by part or entire of ACID.

Enabling and disabling the flight plan track display could also be achieved via the HMI.

3.1.10.13 Personalized Position Parameters Setting

The system is recommended to provide flexible configurations, including label layout, HMI colors, mouse and keyboard functions, color configurations of all elements, menus, and windows according to operational demand.

3.1.10.14 SSR Code Duplication Warning

When detecting multiple aircraft with the same SSR code in a certain area, the system is suggested to provide an SSR Code Duplication warning to the controller.

3.1.10.15 AIDC Coordination Failure Warning

On failure of AIDC coordination, the system is advised to provide visual indications to controllers on track labels and electronic flight strips.

3.1.10.16 SPI Indication

The system provides visual indications to controllers at the reception of SPI information transmitted by the aircraft.

3.1.11 Recording and Playback Function

The Recording and Playback function enables the recording of operational data of ATMAS. It allows synchronized playback of the air traffic situation, controller-pilot communication, and controller actions in the air situation display for incident analysis and investigation. The recording and playback could be implemented as part of ATMAS or via an external recording system. The design should aim at reconstructing the actual scenario as accurately as possible.

3.1.11.1 Recording Function

The Recording Function for ATMAS should maintain a continuous recording on all controller working positions. The following data and display could be considered to be recorded by the system:

- a. Screen data of controller working positions, including an identical picture of windows, temporary maps, and any alert /warning, etc.
- b. Surveillance data, including SDP track output, radar data, ADS-B data, etc.
- c. Controller input actions on keyboard or mouse.
- d. Messages of external interfaces such as AIDC messages, meteorological messages such as GRIB, AFTN, ICAO messages (including flight plan data), ADEXP messages, data links such as PDC, CPDLC, ADS-C.
- e. System data such as system event data, system performance data, system log, etc.

The recording of data and display is suggested to be synchronized with a deviation of less than 1 second or an acceptable tolerance according to the local operational needs. The deviation is suggested to be as minimal as possible to allow the best reconstruction of the recorded scenario during playback.

The Recording Function should ensure no loss of data at all times during the operation of ATMAS, and the recording process should not render any degradation to the performance of other functions of ATMAS. Recorded data should be retained for at least 31 days or a duration which satisfies local regulatory requirements. Some States may require a longer recording period for other purposes e.g., requests for data from other organisations. Periods of 90 or 120 days may be more applicable for such needs. Appropriate warnings are needed for notifying maintenance personnel when storage capacity drops below a certain threshold so that appropriate action could be taken to resolve the situation.

3.1.11.2 Playback Function

The ATMAS or external recording system should allow the replay of recorded and archived data onto designated or idle controller working positions. In general, a playback session should be able to start up within a short period of time and allow continuous replay of recorded data for a considerable duration according to operational needs. The system shall support synchronized playback of voice data.

The following two modes of playback are suggested for implementation in ATMAS to cater to different investigation scenarios:

- a. Passive Playback

The system replays what was on the screen of controller position with recorded and archived data at the period of recording without interaction

- b. Interactive Playback

The system replays the air situation display of the controller' working position at the period of recording. Controller tools, such as change of display range, range, and bearing line, separation probe, quick look, altitude filtering, map selection, etc., are allowed to be used interactively during playback.

For both of the above playback modes, the system should allow synchronized playback of voice data in order to provide a complete picture of events for investigation purpose. To facilitate the playback, the following controls are recommended to be included in the playback function of ATMAS or external recording system:

- a. Start / Pause (Resume) / Stop of a playback session.
- b. Selection of different playback speeds at least real-time speed and a range of playback speeds faster than normal recording speed.
- c. Allow to select a start time for playback in terms of minute.
- d. Selection of playback mode.

The system is suggested to be capable of performing multiple playback sessions simultaneously to allow the playback of the same or different scenarios using different controller working positions. For the same playback session, synchronized replay of recording multiple controller working positions could be considered as part of the playback function to facilitate the investigation of events involving multiple control sectors.

The screen dump function is recommended to capture the screens during playback and store them as files for subsequent printing and exporting. The facility should be provided for exporting the screen dump file to external media using a common image format that could be viewed on computers using non-proprietary software readily available in the market.

3.1.11.3 Data Archiving

Data Archiving function is needed in ATMAS or external recording system for transferring recording data onto removable media for the backup or impounding purpose. The archiving process could be initiated in the system via manual action or configured automatic process based on criteria, e.g., periodic archiving process at a defined time interval or when remaining storage dropped below a certain threshold.

In general, the archiving process should not interfere with normal recording and playback processes in the system as well as other system functions. Appropriate warnings should be given whenever there is an error, or the archiving media is full during the archiving process.

3.1.12 System Monitoring and Control Function

The system is recommended to provide the monitoring and controlling function, and the failure of the monitoring and controlling function should not affect the operation of other modules.

3.1.12.1 Monitoring Function

The system is suggested to monitor in real-time the operational status of each module and display the significant events. Alerts could be raised in levels according to severity, and log files are generated accordingly. The system should be able to search, print, and export logs by time. Usually, the system monitoring function mainly includes:

- a. Interface status monitoring.
- b. Hardware operation status monitoring.
- c. Software operation status monitoring.
- d. Network equipment operation status monitoring.
- e. Database operation status monitoring.
- f. System capacity and resource usage monitoring.
- g. Important system events monitoring.

3.1.12.2 Control Function

In general, the system controlling function mainly includes the operations of start, stop, restart, and switch as follows:

- a. Start and stop the entire system.
- b. Start and stop single surveillance source.
- c. Start and stop a single server.
- d. Start and stop network.
- e. Switch between redundant equipment and networks
- f. Start and stop software modules.

3.1.13 GNSS Time Synchronization

The system is suggested to be able to access an accurate time source, synchronize external GNSS signals, and calibrate internal system time based on the NTP (Network Time Protocol), so that the system time is consistent with the UTC.

The system is capable of receiving multiple external clock sources and switching among them automatically or manually.

If all the external clock signals are interrupted or lost, the system is proposed to synchronize with internal time correspondingly.

Unified time within the system is recommended to be shown on the HMI and provided for surveillance data processing, flight data processing, monitoring and controlling, recording and playback, etc.

3.2 System Optional Function

3.2.1 Extended Surveillance Data Processing

Except for PSR and mode A/C radar data, the extended surveillance data include Mode S radar data, ADS-B data, WAM, and other surveillance data, which contain more target information, such as DAP parameters and accuracy, etc.

The system is encouraged to be able to process the extended surveillance data to provide higher quality tracks and supplementary data.

The systems should be able to receive, process and display data from all the connected sources in an integrated manner. When extended surveillance data is connected, in addition to the essential surveillance data processing requirements (see 3.1.1), the following additional requirements is suggested to be met.

The system can filter anomalous data according to the sensor type. Anomalous data filtering can be carried out during pre-processing, mono-sensor data processing, and multi-sensor data processing. Some suggested anomalous data filtering is as follows:

- a. The system should check the integrity of mandatory data items in the ADS-B message. And only ADS-B messages containing all mandatory data items will be processed. Refer to ICAO APAC's [*GUIDANCE MATERIAL ON GENERATION, PROCESSING & SHARING of ASTERIX CATEGORY 21 ADS-B MESSAGES*](#) for definitions of ADS-B mandatory data items.
- b. The system should check the quality indicators of ADS-B data and position accuracy of WAM data to ensure that only the data meeting the operational requirements is used for track tracking and fusion.
- c. Downlink aircraft parameters rely on airborne equipment besides surveillance system, and their data quality is affected by more factors. It is recommended that the system should perform the validity and consistency check of downlink aircraft parameters.
- d. Due to the anomalous Mode S SSR DAPs caused by BDS SWAP, it is recommended that the system performs additional verification for Mode S SSR DAPs, for example, cross-verification of SSR DAPs from different radar stations.

The system should be able to use the ICAO 24bit aircraft address and aircraft identification for track tracking and correlation.

The system should be able to process the extra emergencies beyond those indicated by codes 7500, 7600, and 7700, including lifeguard/medical, minimum fuel, and downed aircraft.

Note: DO-260 systems only transmit EMG and don't transmit a MODE A code. DO-260A systems broadcast Mode A information using a test message field. DO-260B systems can transmit the MODE A code. While emergency status

can be transmitted by all version of ADS-B transponder. Considering aircraft equipped with DO-260/DO-260A ADS-B transponder in airspace covered only by ADS-B, ATMAS should be able to identify the aircraft's emergency status based on the emergency status of the ADS-B data only.

Mode S radar, ADS-B, and WAM systems can detect aircraft on the ground. The system should be able to process ground/air flags to filter unnecessary ground targets.

The system should be able to process Mode S conspicuity code. Mode S conspicuity code is a standard and non-discrete Mode 3/A code to tell the ATMAS that this is a Mode S equipped aircraft. ATMAS should not use Mode S conspicuity code to identify the aircraft, correlate the flight plans. Instead, the ATMAS should make of the Mode S interrogated information, such as aircraft identification or ICAO 24bit aircraft address, to identify the aircraft and correlate the flight plan. Asia Pacific region adopts “1000” as Mode S Conspicuity Code.

3.2.2 Extended Correlation

On the basis of the original automatic correlation conditions, the system could further perform correlation for a surveillance track and a flight plan based on the aircraft's 24-bit address or Aircraft Identification (ACID) provided by the aircraft downlink parameters.

The system is recommended to give prompts on the correlated track label when SSR codes, aircraft 24-bit address, or ACID of the flight plan mismatch the ones of the surveillance track.

3.2.3 Extended Alert, Warning, and Advisory Function

In addition to the Safety Net Functions stated in paragraph 4.1.5, States/Administrations could consider implementing the following extended set of alert, warning, and advisory functions in ATMAS according to the local environment and operational needs. These optional functions aim at enhancing operational efficiency and possibly reducing controller workload.

3.2.3.1 Departure No Transgression Zone (DTZ)

The Departure No Transgression Zone (DTZ) function informs the controller if a track is predicted to infringe a Departure No Transgression Zone area within a predefined time interval, or has already infringed a Departure No Transgression Zone area. The DTZ function also may suppress improper STCA generate between two normal flights in DMA(Departure Monitoring Area).

The DTZ is an offline defined volume capturing the departure path of aircraft taking off between two extended runway center lines which aircraft is not allowed to penetrate. It shall be possible to define DTZ area off-line by specifying associated DMA (Departure Monitoring Area).

When a track is predicted to infringe an DTZ area within a predefined time interval, or has already infringed an DTZ area, the system shall provide DTZ warning.

- a. The system shall generate DTZ warning for a track predicted to infringe an

active DTZ area within a predefined time interval.

- b. Visual and aural signals shall be provided on concerned controller positions on DTZ warning is raised. The system shall enable operators to acknowledge the raised warning to cancel the aural alarm.
- c. The system shall be allowed to define multiple DTZ areas and activate or deactivate online.
- d. The system shall have STCA filtering function within an active Departure Monitoring Area.

3.2.3.2 No Transgression Zone Alert

In the context of parallel approaches, No Transgression Zone (NTZ) is generally defined as the corridor of airspace between two extended runway centerlines that aircraft are not allowed to penetrate. The purpose of the NTZ alert is to warn controllers of a predicted or actual unauthorized penetration of NTZ by aircraft during the final approach. An appropriate look-ahead of the predicted NTZ alert is important to allow enough time for controllers to respond to the situation.

When a track is predicted to infringe an NTZ area within a predefined time interval or has already infringed an NTZ area, the system shall provide an NTZ warning.

- e. The NTZ warning function includes two parts: NTZ pre-warning and NTZ warning.
- f. The system shall generate a pre-NTZ warning for a track predicted to infringe an active NTZ area within a predefined time interval.
- g. The system shall generate an NTZ warning for a track having infringed an active NTZ area.
- h. Visual and aural signals shall be provided on concerned controller positions on which pre-NTZ or NTZ warning is raised. The system shall enable operators to acknowledge the raised warning to cancel the aural alarm.
- i. The system shall be allowed to define multiple NTZ areas and activate or deactivate online.

3.2.3.3 Medium Term Conflict Detection Warning

Medium Term Conflict Detection (MTCD) is designed as a safety advisory tool that provides warnings to controllers for potential conflict for "aircraft-to aircraft" or "aircraft-to-airspace" encounters up to a looking ahead time. The aim of MTCD is to proactively provide possible conflict in advance during sector planning to reduce tactical workload.

States/Administration should consider the following factors to determine the applicability of MTCD to their local environment:

- a. Suitability of local airspace structure to cater for long look-ahead time.
- b. Local air traffic control procedures.
- c. Whether airspace is under Free Route Operation.
- d. CNS capability to support application.

MTCD advisory could be considered implemented in the following situation:

Potential or risk conflict detected based on current track trajectory and trial clearance/probe. While a controller inputs a clearance, the MTCD will be calculated, and conflict information, if any, will be provided to the controller and prompt for a confirmation to proceed or abort. If a confirmation to proceed is received, an MTCD warning would be generated to concerned controllers with the jurisdiction where conflict may occur.

The MTCD function shall generate visual and/or aural alerts to controllers in air situation display if any pair of aircraft is violating within a look-ahead time, which is a pre-defined separation minimum in the MTCD settings. If more than one type of conflict is implemented, different visual presentations are recommended for each type of conflict to avoid confusion of alerts. In addition, MTCD inhibition could also be implemented based on airspace, flight rule, SSR code groups, ACID, or other conditions applicable to the local environment and operational needs.

3.2.3.4 Route Adherence Monitoring

Route Adherence Monitoring (RAM) monitors if an aircraft (i.e., surveillance track) is following the planned route, as stated in the associate flight plan.

When an aircraft is detected to have deviated from the ATMAS trajectory by more than a defined tolerance, a visual/or aural warning shall be generated to alert controllers to take action on the situation.

In the case of the RAM caused by an incorrect Flight route, the warning may be suppressed after the controller amends the flight plan route to reflect the actual flight path by a user-friendly route modification interface (e.g., Graphical Re-route function).

The RAM warning can be acknowledged manually.

The RAM route model could be defined by the width of the corridor and the radius of the waypoint. It is recommended that the system is designed to allow the definition of different route model parameters for specific route segments.

3.2.3.5 Cleared Level Adherence Monitoring

Cleared Level Adherence Monitoring (CLAM) monitors the conformance of the Actual Flight Level (AFL) of an aircraft to the Cleared Flight Level (CFL) issued by the air traffic controller and provides warnings if the deviation between the two levels (i.e., Level Bust) was found after the aircraft has been level-off. To reduce nuisance alerts, the system could allow an adaptable tolerance on the deviation of AFL from CFL.

States/Administrations can consider including the use of Mode S DAPs, Selected Altitude, in the CLAM detection logic. Selected Altitude is the altitude inputted by the pilot at the aircraft cockpit based on the clearance from controllers. The checking of Selected Altitude with CFL in the CLAM logic could allow early detection of potential Level Bust and alert controller in advance.

3.2.3.6 Similar Callsign Advisory

Similar Callsign Advisory (SCA) provides advisory to alert controllers when an aircraft carries a similar callsign with another one in the same jurisdiction controlled by a controller. According to the operational environment and local needs, SCA checking rules could be pre-defined or pre-programmed at the design stage of ATMAS implementation. Adaptable SCA checking rules or look-up tables are preferred to allow modification of similar callsign checking process based on the latest requirement and feedback from controllers.

3.2.3.7 Reduce Vertical Separation Minimum Warning

Reduce Vertical Separation Minimum (RVSM) Warning provides alerts to controllers when a non-RVSM approved/compliant aircraft is within or is predicted to enter RVSM airspace.

To provide the warning to controllers, the volume of RVSM airspace would need to be defined in the ATMAS, and the Field 10 of ICAO flight plan would be checked to see if the aircraft is RVSM-approved. Visual indication would be generated if the aircraft did not match the airspace requirement on RVSM.

3.2.3.8 Position Report Monitoring

The ATMAS trajectory needs to update for every point inside the route model when the aircraft overflow this point. Position report permits a more precise calculation of the Estimated Time of Overflight (ETO) of subsequent points along the planned route. The Position Report shall also include intent information from Surveillance reports for use in trajectory estimation.

To make the maintenance staff aware of the inconsistency in position reports, Position Report Monitoring (PMON) monitors ATO/ETO and provides warnings to controllers when:

- a. Actual Time Over (ATO) and/or Estimated Time Over (ETO) of the next report point differs from that calculated by the flight trajectory by more than a defined time interval
- b. The ETO of the respective waypoint differs by more than a defined time interval
- c. No position report is received for a defined time interval after the ETO missed the position report

3.2.3.9 Last Known Position Display

Last Known Position Display occurs when correlated tracks, uncorrelated, or ADS-C tracks with critical alerts are lost.

The last known position of the track is displayed with a special track symbol to the dedicated position.

3.2.3.10 SSR Inconsistency Warning

For correlated flight plan tracks, when the Mode 3/A code in the surveillance data is inconsistent with the SSR code in the flight plan, the system is suggested to raise ASSR Inconsistency Warning.

NOTE: 24-Bit Code Mismatch Warning and Callsign Mismatch Warning, please refer to chapter 3.2.4.2.

3.2.3.11 PBN Capability Indication

The PBN function shall provide PBN indicator and/or PBN route mismatch indication for controllers in order to indicate whether the aircraft match the RNAV/RNP Route or Arrival.

When the PBN indicator is presented in the flight plan message, the system is suggested to determine the PBN capability of the aircraft and inform controllers of the PBN capability.

It is proposed that the system could define different priorities of PBN capability display for each logical position.

The PBN function shall provide PBN route mismatch indication to the controllers:

- a. When PBN route is mismatch between offline defined and PBN of flight plan message.
- b. It shall be raised at offline define time prior to the route segments.
- c. It shall be able to offline turn on or off.

3.2.3.12 Downlink Aircraft Parameters Related Warnings

Please refer to section 3.2.4.2 for Downlink Aircraft Parameters related warnings.

3.2.4 Downlink Aircraft Parameter Processing and Display

It is recommended that the system have the capability to process and display aircraft downlink aircraft parameters (DAPs) from Mode S radars, ADS-B and/or WAM to help controllers have a more integrated view of the aircraft's flight status in the air.

3.2.4.1 DAPs in Consistency Checks

The system is capable of making use of DAPs for report consistency checks, altitude and position tracking. The data in DAPs include the magnetic heading, true airspeed, selected altitude, barometric vertical rate, geometric vertical rate, roll angle, track angle rate, track angle, and ground speed, etc.

3.2.4.2 DAPs Related Warnings

DAPs Related Warnings generally include:

a. 24-Bit Code Mismatch Warning

For the correlated track, the system can provide an ICAO 24-bit code mismatch warning and present to the responsible controller when the downlink 24-bit code does not match the CODE in field 18 of the FPL message.

b. Callsign Mismatch Warning

For the correlated track, the system can provide a callsign mismatch warning and present it to the responsible controller when the downlink callsign does not match the callsign in field 7a of the FPL message.

c. Predicted Level Mismatch Warning

The system is suggested to continuously monitor the consistency of Selected Altitude from the airborne equipment and the Cleared Flight Level from the controller. A predicted level mismatch warning will present to the responsible controller if the difference is greater than the pre-defined threshold.

d. Resolution Advisory (RA) alert indication

The system may provide a RA alert indication and present on the track label to the responsible controller when a RA report is received via the airborne ACAS system.

Note: The display of ACAS Resolution Advisory Report in ATM automation system can be turn on or turn off by user, and it is not recommended by IFATCA. The user is suggested to do the relevant safety evaluation before applying this function.

3.2.4.3 DAPs Display

The system is suggested to provide a downlink data window, which is used to display the downlink aircraft information. Displayable information is recommended to include: SSR code, Target aircraft address, Target aircraft identification, Magnetic heading, True airspeed, Selected altitude, Final state selected altitude, Barometric vertical rate, Geometric vertical rate, Roll angle, Geometric vertical rate, Track angle rate, Track angle, Ground speed, Velocity uncertainty, Position uncertainty, Indicated airspeed, Mach number, Barometric pressure setting, etc.

The information in the DAP Window can be configured per logical positions, such as the airborne downlink data to display and the unit of data items, etc.

3.2.5 Arrival Manager Function

The purpose of Arrival Manager (AMAN) is an advisory tool to optimize the flight landing sequence with suggested arrival interval and reduce flight holding time in the air, thus minimizing delay and providing control actions and advisories. These are achieved by considering factors such as airport runway configuration, runway rate, weather conditions, stand arrangements, etc.

The essential functions of AMAN include flight sequencing, spacing, and delay advice.

a. Flight sequencing and spacing function

According to the calculated four-dimensional trajectory, AMAN calculation takes into account the metering point or runway spacing and performs a sorting calculation to obtain the target landing time (TLDT) and the arrival sequence. The tool recalculates the TLDT, when it obtains a new estimated landing time (ELDT), or when ATC reissues a request to revise the metering point or runway spacing.

b. Delay advice function

The delay advice generated by AMAN includes re-route, holding pattern, point merge system (PMS), and delay time indication. The system gives different delay advice according to the time of the delay.

AMAN may interact with ATFM or CDM system to follow a strategic plan to balance capacity and demand within different volumes of airspace and airport environments. There are many types of ATFM measures. Their lifetime typically spans the pre-tactical and tactical phases of the ATFM timeline. Fix balancing, Re-routing (mandatory or alternative), Level capping scenarios, and Collaborative trajectory options are included in the lateral aspect. For details and more information, please refer to DOC 9971.

3.2.6 Departure Manager Function

The basic function of DMAN shall include stakeholders to file Target Off-Block Time (TOBT) to a particular flight and ATC to calculate Target Take-Off Time (TTOT) which in turn issues a Target Startup Approval Time (TSAT). DMAN should also take in Calculated Take-Off Time (CTOT) from Flow Managers to apply ground delay programs.

The purpose of Departure Manager (DMAN) is to allow the operator to plan flights and share the planning decisions with other operators enabling Airport Collaboration Decision Making (A-CDM) to optimize departure sequence. This reduces fuel wastage by reducing taxiing and waiting time on taxiways.

a. Filing TOBT

When operators and stakeholder to file a TOBT, it enables ATC to know when the aircraft will be ready for pushback. This enable better predictability of flight readiness

b. Calculating TTOT and TSAT

With a known TOBT, DMAN will calculate a take off time for this flight. If take off time is free of conflict, TSAT will be TOBT. If take off time is occupied by another flight, DMAN will find the next available take off time base on system set departure interval and wake constraint, forming the TTOT. TTOT will be back calculated by deducting taxiing time to runway and pushback time deriving a TSAT. In this case, TSAT is not the same as TOBT thus a delay advice in gate is issued.

c. Taking CTOT into consideration

d. If ground delay program is needed, Flow Managers will issue a specific CTOT to a flight. This will then replace TTOT of the flight and DMAN will back calculate by deducting taxiing time to runway and pushback time deriving a TSAT. This CTOT shall be within system configured constraint and other non CTOT flights to be sequenced around it.

DMAN can be enhanced by introducing Surface Manager (SMAN) which will feed taxiing time to DMAN base on ground sensors rather than a fix system configured table.

3.2.7 System Log Management

For the convenience of anomalies investigation, the system is recommended to be able to collect and manage operational logs and error messages. The operational logs include

personnel commands, hardware logs, software logs, external interface logs, etc. The error messages consist of software and hardware error messages, etc.

The system is suggested to be capable to:

- a. Record operational logs and error messages.
- b. Display necessary logs on the dedicated positions.
- c. Store logs on the disk and classifies by dependency. The user is allowed to sort logs by given conditions.
- d. Backup logs automatically or manually, and the backup logs are readable.
- e. Store logs on the disk for at least 31 days.

3.2.8 Enhancement Recording and Playback Function

Considering the convenience to user, the system is recommended to extend the capability to integrally record the screenshots of the HMI by way of frames and replay the recording onto designated positions and mobile devices in the form of video.

3.2.8.1 Video Recording Function

The video record refers to the continuous footage derived from the controller's screen as exactly the same as shown. The video recording data is recommended to output as common video formats.

The system is suggested to support the storage of video recording data over a period of time, such as 31 days. By reducing disk occupancy and transferring the data for the method, the system should not be impacted by storage overload.

3.2.8.2 Video Playback Function

It is recommended that the replay of the video record data could be performed on any designated controller position, and the video replay should be synchronized with the Audio.

The system is expected to be able to control the replay, including the selection of replay mode, retrieval replay, change replay speed, start, pause, forward, stop, etc.

3.2.9 Enhanced Wake Turbulence Separation and Pairwise Separation Tools

Amendment 9 of the PANS-ATM (Doc 4444) introduces a new enhanced wake turbulence separation scheme with an alternative set of wake turbulence groups and associated wake turbulence separation minima for approach and departure phases of flights. The new scheme is based on the studies performed by Federal Aviation Administration (FAA) and European Organization for the Safety of Air Navigation (EUROCONTROL) on the wake generation and wake resistance characteristics of different aircraft types, which allows a reduction in wake turbulence separation between some aircraft pairs depending on the leading and the following aircraft type, as well as

increases in wake turbulence separation for the smaller and more vulnerable aircraft type.

The ICAO Flight Plan is not required to be updated with the new wake turbulence groups, while air traffic controllers will have to consider seven wake turbulence groups instead of four categories when applying the new wake turbulence separation minima. States/Administrations are recommended to implement Pairwise Separation Tools function in ATMAS to assist air traffic controllers in the delivery of intended aircraft separation under the new scheme without memorizing all the separation pairs.

3.2.9.1 Wake Turbulence Groups and Airspace

The harmonized ICAO wake turbulence group categorizes aircraft into seven groups, Groups A to G, based on maximum certified take-off mass and wing span:

For the implementation of enhanced wake turbulence separation scheme, States/Administrations have the flexibility to determine the scope of applicability to their airspaces. Also, States/Administrations can consider introducing the reduced minima in total, or in part as the first step, or a combination of these with fewer groups, or updating the local minima based on a partial set of enhanced wake turbulence separation minima, whichever will provide the most benefit given the local traffic mixture.

To facilitate the transition from legacy to new scheme by air traffic controllers, the design of ATMAS should allow the flexibility to adapt the mapping of wake turbulence groups (A to G) to a custom set of abbreviations according to the local operational environment to minimize the impact to air traffic controllers in handling extra wake turbulence groups under the new scheme.

States/Administrations would need to define the specific volume of airspace that operates using ICAO enhanced wake turbulence separation, whilst other airspaces should continue to operate using legacy ICAO wake turbulence categories. For the implementation, the design of ATMAS should allow the use of both wake turbulence categories and groups in the system so that the appropriate wake turbulence categories/groups could be applied based on airspaces, controlling sectors, or controller's roles in accordance to operational needs.

3.2.9.2 Human Machine Interface of Wake Turbulence Groups

The abbreviation of wake turbulence categories/groups is normally displayed in the track labels of an aircraft in the HMI of ATMAS. Since the enhanced separation would only be implemented in the designated volume of airspace, the ATMAS should be configurable to display the appropriate wake turbulence categories/groups to air traffic controllers in accordance with the applied wake turbulence scheme of that airspace. The ATMAS could determine the appropriate scheme by referring to the location of the aircraft and/or roles of the controllers.

In addition, States/Administrations can consider implementing electronic cue cards on the pair-wise aircraft separation under wake turbulence groups in ATMAS to assist controllers in identifying the required separation for aircraft pairs during operation.

3.2.9.3 AMAN Optimization

With the implementation of ICAO enhanced wake turbulence separation, runway capacity is expected to increase in most cases due to a general reduction of wake turbulence separation in popular aircraft pairs of traffic mix. To benefit from the increase in runway capacity, the AMAN would need to be optimized to provide plans with arrival rate matching the runway capacity. The optimization could involve a change in the AMAN logic on handling extra wake turbulence groups or fine-tuning of system parameters to increase the arrival rate of the landing sequence generated by AMAN to match with the theoretical runway capacity as far as possible.

3.2.9.4 Pairwise Separation Tools

To assist air traffic controllers in handling air traffic under enhanced wake turbulence separation and improve air traffic controllers' consistency in delivering the traffic according to the intended runway capacity, Pairwise Separation Tools are recommended to be implemented. There are several examples of such tools in use, the following tool, namely Approach Spacing Tool (AST), provides an example of the function and application of such tools. The AST could project and present the required spacing graphically between aircraft pairs along the approach sequence and provide advisories, in the form of graphical indicators on the Air Situation Display, to indicate the optimal positions of aircraft along the final approach path.

The AST could be operated in either Distance-based Separation (DBS) or Time-based Separation (TBS). Time-based Spacing could be helpful in safely managing the traffic without reduction in capacity when aircraft ground speed is generally reduced on the final approach due to strong and consistent headwinds. States/Administrations should assess separation standards by considering the performance/accuracy/reliability of local wind prediction, time-to-fly forecast, and other relevant ATC support tools.

Projection of Spacing

During the computation of spacing guidance, the AST should consider all the required separation criteria for a given aircraft pair, including wake turbulence separation minima, minimum radar separation, and dependent parallel approach separation. Then the tool would apply the most stringent criteria to ensure that none of the required separations is infringed.

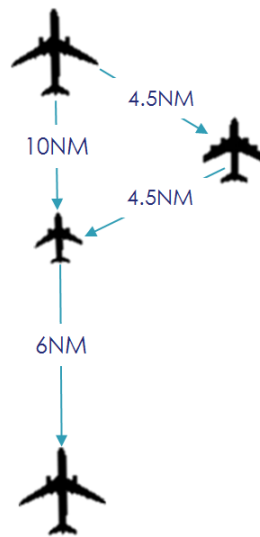


Figure 3.2.8-1 Minimum Separation

Apart from the required minimum separation, the AST would also consider other operational situations or parameters which could affect the optimal spacings between aircraft such as runway occupancy times, specific minimum separation defined for a runway, extra gap required between specific landing aircraft, etc. Together with the operational mode on the aircraft spacing and runway mode, the AST would consider all the above factors and provide spacing guidance in the form of graphical cues illustrated in the subsequent paragraphs.

AST Guidance Cues

Provision of visual guidance on the computed spacing, in the form of graphical indicators on the Air Situation Display, is recommended as part of the AST function. The purpose of visual guidance is to support air traffic controllers in delivering the traffic according to the intended capacity as far as practicable. Two guidance cues are recommended to be implemented by the AST:

- a. Final Target Distance (FTD)
- b. Initial/Intermediate Target Distance (ITD)

Final Target Distance (FTD) is the appropriate position for the following aircraft behind a leading aircraft at the required minimum spacing applied at the runway threshold. The follower shall always be behind its respective FTD indicator along the final approach path.

Initial Target Distance (ITD) is the optimal distance for the following aircraft to be positioned behind a leading aircraft with the consideration of the required minimum spacing and the deceleration compression buffer. The ITD should be calculated based on the estimated 3D trajectory, the estimated speed profile, environment data (including wind, temperature, etc.), and the target FTD.

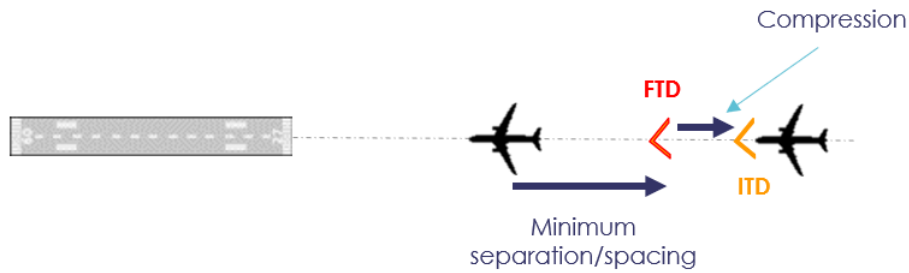


Figure 3.2.8-2 FTD and ITD Guidance

FTD and ITD guidance should be updated at every track update of ATMAS. Depending on the actual operational environment, the position of the FTD and ITD guidance cues could be chosen to implement in AST along:

- a. Planned trajectory of the flight.
- b. Predefined common path.

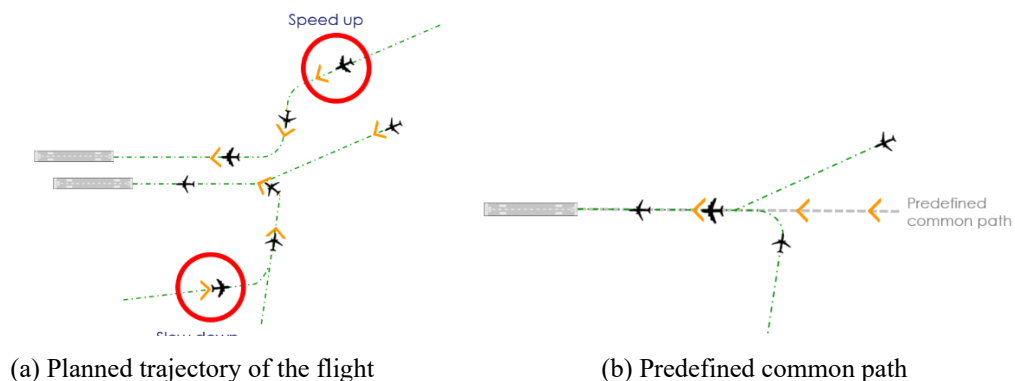


Figure 3.2.8-3: Guidance Cues

Final Approach Sequence Management

The planned Final Approach sequence is crucial in the generation of AST Guidance Cues by providing necessary information to the AST in determining the required wake turbulence separation between aircraft. Therefore, an accurately planned sequence is important for smooth AST operation.

If State/Administration has implemented Arrival Manager (AMAN) in its operation, its arrival sequence data would be the best candidate for processing by the AST. If AMAN is not available, an arrival sequence based on the flight trajectories from ATMAS would be an alternate option for AST processing.

Monitoring Aids in Approach Spacing Tool

To ensure the appropriate spacing between arriving aircraft can be delivered, the following monitoring aids could be implemented for aircraft under management by AST for detecting catch-up scenarios, infringement of aircraft spacing, arrival sequence mismatch, speed non-conformance, etc..

3.2.10 Operational Data Synchronization

In order to provide continuous ATM service in case of the ATMAS suffers from technical problems, system failures, or other critical anomalies, some ATM centers are configured with two types of ATM automation systems, which work in main and backup mode.

The Operational Data Synchronization Function serves for both master and backup ATM automation systems deployed in the same ATM center. This function enables the system to synchronize operational data to the backup system when in master mode. This function also synchronizes the system when in backup mode with operational data from other master systems.

3.2.10.1 System Main/Fallback Mode

The system provided with the operation data synchronization function shall have two working modes at least: main and fallback mode. These two working modes can be switched manually.

In the main mode, all of the system functions operate normally and output synchronization data in real-time.

In the fallback mode, the system receives and processes the synchronization data in real-time. System functions run as usual, apart from the transmission of messages to external systems.

3.2.10.2 Synchronous Data

Data synchronous data between the main and fallback systems is recommended to include basic flight data and operational setting data as follows. Users can adjust the data to be synchronized based on the operation needs:

- a. Basic flight data comprises flight plan information, allocated runway, SID/STAR, etc.
- b. Operational setting data includes sector allocation, airport runway status, position settings, online area creation or modification, etc.

3.2.10.3 Synchronization Trigger

Data synchronization is recommended to carry out periodically at a pre-defined time interval. In addition to the periodic data synchronization, the synchronization could be triggered by pre-defined events, for examples:

-
- a. Each item in the flight plan information changed.
 - b. Each flight plan state changed
 - c. Each operational setting changed.

3.2.11 Statistics and Analysis Function

Statistics and analysis function could be implemented for generating reports on the surveillance data, flight plans, alarm information, and traffic flow data.

Flight data that can be extracted from the ATMAS database at a minimum would have the following correlated data fields: aircraft ID¹, number of aircraft movements in the airspace sector and controlled airspace², flight rule³, flight type⁴, number of danger area infringements, number of rejected & accepted uplink messages, number of rejected & accepted downlink messages, number of uplink & downlink delivery timeouts, number of received and transmitted messages, number of AIDC messages⁵ (transmitted, received, rejected, and accepted) and the total number of flights.

Presentation of correlated data fields would be in the form as shown in Appendix B: **Table 3.2.10-1A for Flight Specific Flight Data and Table 3.2.10-1B for Collective Flight Data**, where these are organized according to the date and/or time (in hour resolution⁶) of interest. The date and/or time window selection will allow flexibility in the period of data of interest. Hence, the correlated data will not be limited to fixed time periods, e.g., daily, weekly, or monthly. Nonetheless, a fixed time period can be the default setting and, in any case, the selected time period that defines the scope/coverage of the data that are being presented in the interface will always be visible to the user.

The data fields for **Collective Flight Data** will refer to the specified time periods. For example, data for the Total No. of Flights will be presented for the Day if the selected Time Period is set to Day; the Total No. of Flights will be shown in each sector for the Airspace Sector; and so on. Furthermore, the Total No. of Flights data need not be equal to the Total No. of Flights in the Airspace Sector when the Total No. of Flights in each Airspace Sector is summed together for the reason that the flight may have traversed more than one Airspace Sector. The same principle is applied in the presentation of other correlated data fields.

Correctness and accuracy of the information in the presented data should be verified prior to deployment of the ATMAS into live operation. This can be arranged as one of

¹ICAO 2012 strictly enforces that this figure should be letters and numbers only, devoid of dashes, spaces, or other punctuation.

²sorted into ARR, DEP, Overflight, and Domestic Flights

³ “I” for IFR, “V” for VFR, “Y” for when the flight will be initially IFR followed by one or more subsequent flight rules changes, and “Z” for VFR first with any number of subsequent changes.

⁴ “S” for Scheduled Air Service, “N” for Non-scheduled Air Transport Operation, “G” for General Aviation, “M” for Military, and “X” for everything else

⁵ applicable to flights involving the exchange of AIDC messages with adjacent FIR/ATS Unit

⁶ the selection of time period will allow up to values in hour, e.g., 19 March 2021 0900-1000 UTC

the test cases for each data field that the vendor must be able to comply verifying its performance.

Similarly, surveillance data correlated with flight data records can be retrieved from the ATMAS. These data are grouped into Flight Specific Surveillance Data.

Flight Specific Surveillance Data should be able to provide information on the type of surveillance track that is/are correlated to the flight. For instance, in a single flight data record, there is information if Secondary, Mode S, Multilateration and ADS-B tracks are correlated to the flight. This applies to an ATMAS interfaced with multiple surveillance technologies. For more than one source of the same type of surveillance technology, information about the source of that correlated track data should be provided, e.g., ADS-B Source: 2 (ADS-B track data taken from the second ADS-B sensor defined in the system). Furthermore, information about the surveillance track quality should also be provided if coasting, normal, low or high. This track information shall be based on the time stamped track at the time of track distribution. The time stamp shall be the reference of the ATMAS for generating the Flight Specific Surveillance Data after selecting the time period of interest. Appendix B **Table 3.2.10-2** illustrates the presentation of **Flight Specific Surveillance Data**.

Considering the number of surveillance tracks generated as system tracks for the ATMAS from a single source alone for one target, it will be quite irrelevant to gather **Collective Surveillance Data**. **Flight Specific Surveillance Data** would be more useful for the analysis of information generated by the ATMAS.

Data records should be retained for at least 31 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. 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 system⁷.

The data can be used for pre- and post-analysis of Air Traffic Management situation. Peri-analysis process will allow the ATC Supervisor to make the necessary adjustment(s) in the operations, while post-analysis can provide guidance in improving the operational processes and activities complementary to the technical aspect of the operations.

⁷ The excerpts from Chapter 7.7.1 of the ADS-B IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT, Edition 8.0 – September 2015 is hereby adopted for all surveillance data sources.

4. SYSTEM DESIGN

4.1 System Architecture

In general, ATMAS should be equipped with adequate redundancy to ensure full availability for all critical, essential, and routine operational functions for air traffic control. Its system architecture should allow extra redundancy to be deployed whenever considered necessary. The architecture of ATMAS should follow the design and implementation principles below:

- a. The ATMAS software should adopt modular design and distributed architecture to ensure robustness under adverse operating conditions. For the key function modules, such as FDP and SDP, they should be at least deployed on dual redundant servers in hot standby configuration to ensure a safe and uninterrupted service of ATMAS.
- b. To minimize the number of single point failures due to hardware or software, multiple system redundancy and distributed system architecture are recommended.
- c. System elements running simultaneously on multiple servers/computers should communicate over redundant networks and the failure of any element should not affect the operation of other system elements.
- d. The network of ATMAS should be built on redundant network elements. Each mainstream operational data should be transmitted over independent links and networks. Failure of any network element would not affect the delivery of the main data stream within ATMAS.
- e. For large-scale ATMAS designed for handling large traffic volumes, it is recommended to separate the transmission of different types of system data into dedicated networks. For example,
 - Operational Network: for handling the exchange of operational data, including surveillance data, flight plans, etc., between all controller working positions and operational servers.
 - Maintenance Network: for the transmission control & monitoring data, maintenance-related data, system log, replay data as well as distribution of new software and adaptation updates to system elements.
 - Direct Surveillance Access Network: for direct distribution of surveillance data from surveillance sources to controller working positions as the backup to the system track output of Surveillance Data Processor (SDP) of ATMAS.
 - Data Synchronization Network: for synchronizing data between

redundant systems of ATMAS.

- f. High reliability through redundancy such that at least two identical system elements of the same function operate concurrently and the failure of either one should not affect the satisfactory operation of its counterpart and the system service.
- g. Fault tolerant such that the system could continue its service, rather than failed completely, when some elements of the system failed.
- h. With fail safe capability such that the system operation should switch over to the fallback system elements after failure or abnormal termination of operational system elements.
- i. Apart from having redundant elements within ATMAS, it is encouraged to implement a separate set of ATMAS as the fallback system to main operational system for maintaining air traffic services in case of catastrophic events happen in the main system.
- j. For ATMAS managing busy airspaces with high traffic volume, the main and fallback systems are recommended to be provided by different manufacturers to avoid common software faults to both systems.
- k. The main and fallback systems are suggested to be physically located at different sites to prevent any single-site accident affecting the operation of ATMAS.
- l. External interfaces of the system (such as radar, AFTN, etc.) shall be redundantly configured and the system support automatic/manual switch to the redundant interface channels in case of partial failure.

4.2 Position Roles and Types

Based on functionalities, positions of ATMAS can be categorized into the different types, e.g.

- a. Controller Working Position.
- b. Flight Data Operator Position.
- c. Flow Management Position.
- d. Technical Maintenance Position.
- e. Data Management Position.
- f. Search and Rescue Position.

States/Administrations is suggested to review their operational needs during the design stage of ATMAS in order to adopt the suitable set of positions for their operational environment.

Working positions can be further categorized based on the user roles. For example, in ATC Center, controller working positions are categorized into roles of Supervisors, Executive Controller, Planning Controller, and Assistants under Enroute, Terminal, and Approach Control Streams. In ATC Tower, controller working positions are categorized into roles of Supervisor, Air / Ground Controls, Clearance Delivery, and Assistant.

Access to different system functions by users would be controlled based on the assigned roles. Controllers would be assigned with controlling roles for flights under their jurisdiction, while maintenance engineers would be granted monitoring and control permission on system components of ATMAS. All the roles and permissions should be offline adaptable in the system database by authorized personnel. Once a role has been assigned to an individual, that person can access the data and functions based on the assigned permission.

States/Administrations could consider strategically deploying extra controller working positions as spare in ATC Center and Tower. If a controller working position fails for some reason, controllers can quickly move to a spare controller working position and continue the ATC operation. The design of ATMAS should allow the restoration of air traffic situation display, flight data, electronic flight strips, display settings, and preferences after controllers move to another position to continue their works.

The type and number of positions shall be deployed on each site according to the operational requirement. For the functions of each position, please refer to section 3.1.10.

4.3 Main and Fallback System Configuration

States/Administrations are encouraged to implement ATMAS in Main and Fallback configuration as the baseline in order to be capable of providing uninterrupted ATC service for their airspace. The Main and Fallback configuration can be achieved by two sets of ATMAS or redundant processors of the same system. The Fallback system should possess comparable system scale, configuration, and software functions with the Main system. In addition, the Main-Fallback data synchronization mechanism should be implemented to ensure the readiness of Fallback system for taking up the role as operational system for air traffic control in case of failures in Main system.

For ATMAS managing busy airspaces with high traffic volume, States/Administrations are encouraged to set up the Main and Fallback ATMAS with the same functionalities, capabilities, and capacities but in separated systems in order to enhance robustness and continuity in providing safe, efficient, and orderly ATC services. In busy airspaces, ATMAS failure could be a catastrophic event and cause disruption to air traffic. The Main and Fallback systems with data synchronization mechanism should allow the switch over between Main and Fallback systems seamlessly when needed. In addition, since the system switch over due to unexpected failure could be a rare event, States/Administrations are suggested to perform the switch over between Main and

Fallback systems regularly to get air traffic controllers and engineers familiar with the process.

To further enhance resilience and mitigate risks of complete ATMAS failure, Main and Fallback systems are recommended to be provided by different manufacturers to avoid common software faults encountered in both systems simultaneously. If Main and Fallback systems with the same functionalities, capabilities, and capacities were supplied by the same manufacturer, a full-fledged Ultimate Fallback system from a different manufacturer would need to be implemented such that the Ultimate Fallback system could take up the operation as last resort in case of common software faults in Main and Fallback systems. The Ultimate Fallback should be designed to have the same level of functionalities, capabilities, and handling capacity as Main and Fallback systems in order to sustain possible prolonged control of the airspace.

For the case of (1) Main and Fallback systems from the same manufacturer or (2) redundant processors of the same system, but without the deployment of Ultimate Fallback system, States/Administrations should conduct safety risk assessment on the overall system architecture to ensure that the risks of having common software faults in both Main and Fallback systems simultaneously have been mitigated to an acceptable level.

Real-time data synchronization function shall be implemented between the main and fallback systems to ensure the data consistency and smooth switch when technical failure. The operational data synchronization function can refer to section 3.2.9.

4.4 System Operation Mode

4.4.1 Normal and Degraded Modes

The ATMAS should be capable of operating in normal and degraded modes. Under the normal mode of operation, all the system elements of ATMAS are running normally with full redundancy. Whenever there is any key system function (such as FDP or SDP) fails, the ATMAS should maintain its service and automatically change to a degraded mode of operation. The degraded mode should allow controllers to maintain the provision of air traffic control service using limited system functionalities for a short period of time while the system issues are being fixed by maintenance staff or switching over to the Fallback system is still underway.

Under FDP failure, the ATMAS would be unable to process new incoming flight plans and existing flight data records in the system. Silent coordination across controller working positions may be unavailable as well. To mitigate the impact, controller working position should keep a local copy of system flight plan data at individual workstations so that flight plan association to the surveillance tracks could be maintained using local flight plan copy upon FDP failure. In this case, controllers could continue to identify tracks under their jurisdiction in their air situation display and maintain the control of traffic.

For SDP failure, the processed multi-surveillance track data from SDP would be unavailable in ATMAS. The system should maintain the display of air traffic situation to the controllers by automatically switching to direct surveillance access mode in which individual sources of surveillance data are directly fed to the controller working

positions without the need for an SDP. In this case, controllers can continue the air traffic control operation using directly fed surveillance data while the SDP issue is being investigated and fixed by the maintenance team.

In case of other failures, the system should display impacted functions and operate smoothly in the absence of degraded functions. When the failed function recovers, controllers are allowed to manually upgrade to the normal mode on the position.

4.4.2 Main and Fallback Modes

For the case with Main and Fallback systems in place, the system should be capable of configuring between Main and Fallback modes. In the Main operation mode, the system would be responsible for processing AFTN messages, assigning SSR codes, responding to controllers' input, communicating with external systems, and synchronizing data to the Fallback system. In the Fallback operation mode, the system would not process carry out the above processing but would receive synchronization data from the Main system and keep the system database up-to-date for operation switchover at any time. Since the Main-Fallback switchover involves the coordination across different controlling streams and technical maintenance team, it is suggested that user should manually switch the Main/Fallback modes at the dedicated position of ATMAS for centralized coordination on the switchover.

Regarding the HMI design, the operational modes should be shown at the controller working positions and technical maintenance positions with prominent indications in case of any degradation of system functionalities. For cases with Main and Fallback systems in operation, the ATMAS should clearly indicate the current mode of operation, Main or Fallback, in its HMI to ensure that controllers are working at the correct system.

4.5 Capacity and Performance

4.5.1 System Capacity

Normally, system capacity is used to describe the maximum processing capabilities, which is determined by the air traffic flow, operation requirements and system architecture, etc. It is suggested to include the following items at least:

- a. System area.
- b. Maximum number of sectors.
- c. Maximum number of positions.
- d. Maximum number of tracks displayed/correlated/under-controlled.
- e. Maximum number of flight plans existing in the system.
- f. Maximum number of flight plans activated simultaneously.
- g. Maximum number of surveillance sensor inputs.
- h. Maximum number of adjacent centers with AIDC protocol.

4.5.2 Response Time

Response time is used to measure the speed, stability and resource usage of hardware and software in the system, the following recommended criteria are listed by experience, States/Administrations are encouraged to consider during the system planning stage.

- a. The duration to start up a single node should be not more than 5 minutes.
- b. The duration to cold start up whole system should be not more than 30 minutes.
- c. MTBF of surveillance data processing should be not less than 100,000 hours.
- d. MTBF of a single workstation should be not less than 10,000 hours.
- e. Maximum deviation of clock synchronization should be not more than 100 milliseconds.

4.5.3 Performance of Surveillance Data Processing

Performance of surveillance data processing is used to measure the accuracy and ability of the system surveillance data processing, the following suggested values would be considered for system planning.

Adhering to the RSUR-5NMSEP_ER_Tier- A in the RSUR manual as attached in Appendix C, recommended surveillance performance requirements for 5 NM horizontal separation are mainly as follows:

- a. The surveillance Data Update Interval (DAT_{UI}) should be less than or equal to 5 seconds.
- b. The Probability of Update (PoU) of horizontal position and pressure altitude should be greater than or equal to 97%.
- c. The Horizontal Position RMS error (HPERMS) should be less than or equal to 230 m or the Horizontal position error distribution at 95% (HPE95%) should be less than or equal to 400 m.
- d. The Pressure Altitude INTeegrity (PAINT) and Mode A code Identity. (IDINT) should be less than 0.1%.
- e. The Pressure Altitude INTeegrity (PAINT).should be less than 0.1%.
- f. Maximum Data Age of a parameter of Horizontal Position (HPMDA) should equal to 15s and Maximum Data Age of a parameter of Mode A code Identity. (IDMDA) should equal to 30s.

Adhering to the RSUR-3NMSEP_TMA_Tier- A in the RSUR manual as attached in Appendix C, recommended surveillance performance requirements for 3 NM horizontal separation are mainly as follows:

- a. The surveillance Data Update Interval (DAT_{UI}) should be less than or equal to

5 seconds.

- b. The Probability of Update (PoU) of horizontal position and pressure altitude should be greater than or equal to 97%.
- c. The Horizontal Position RMS error (HPERMS) should be less than or equal to 150 m or the Horizontal position error distribution at 95% (HPE95%) should be less than or equal to 260 m.
- d. The Pressure Altitude INTEgrity (PAINT) and Mode A code Identity. (IDINT) should be less than 0.1%.
- e. The Pressure Altitude INTEgrity (PAINT).should be less than 0.1%.
- f. Maximum Data Age of a parameter of Horizontal Position (HPMDA) should equal to 15s and Maximum Data Age of a parameter of Mode A code Identity. (IDMDA) should equal to 30s.

4.5.4 Capacity of Recording and Playback

Generally, the capacity of recording and playback refers to the storage time of data in the system, and the following proposed values would be used as information during system design.

- a. The minimum period for recording data archived in the system should be not less than 31 days.
- b. The minimum period for system traces should be not less than 31 days.
- c. The minimum period for raw surveillance data archived in the system should be not less than 7 days.

4.6 External Interfaces

External interfaces are used to communicate with other systems, including receiving and transmitting messages.

The selection, configuration, and design of external interfaces can be determined by environmental conditions, operational requirements, and long-term schemes.

States/Administrations can determine the external interface of the ATMAS. In general, ATMAS includes the following external interfaces:

- a. Surveillance data interface
 - Radar interface

The system is recommended to manage dual inputs from individual radar with serial or Ethernet interface and be able to receive and process the plots/tracks in a standard format, including ASTERIX.

➤ ADS-B interface

The system is suggested to manage dual inputs from individual ADS-B with serial interface or Ethernet and be able to receive and process ADS-B data in a standard ASTERIX CAT021 format.

➤ WAM interface

The system is recommended to manage dual inputs from WAM data processing center with Ethernet, and be able to receive and process WAM data in a standard format, including ASTERIX CAT020 from Ethernet.

b. ICAO message interface

The system should be able to receive and transmit the ICAO messages automatically in IA5 or ITA2 format with the asynchronous serial interface.

c. AIDC Interface

The system should be able to exchange the AIDC messages compliant with the standard AIDC protocol on the AFTN line and/or dedicated line.

d. Meteorological interface

➤ QNH interface

The system should be able to process the QNH data from the AWOS system with an asynchronous serial interface.

➤ GRIB interface

The system should be able to receive and process the GRIB message from Ethernet.

e. Data synchronization and exchange interface

➤ System track interface

The system should be able to receive and transmit the system tracks with serial interface and Ethernet in ASTERIX CAT 062.

➤ Flight data exchange interface

The system should be able to receive and transmit flight data with serial interface and Ethernet in the message format agreed.

➤ Audio playback interface

The system is recommended to be able to provide the interface to synchronize the playback activities with the audio in an agreed data format through a serial interface or Ethernet, which can keep the playback of audio and situation awareness synchronization in time.

f. GNSS time interface

The system should be able to receive the GNSS time from the time reference system with Ethernet NTP protocol or serial interface.

g. CPDLC interface

The system is suggested to enable communication with external CPDLC equipment in compliance with the FANS1/A, ATN B1 data formats through Ethernet or serial interface.

4.7 Systems Interoperability

The system interoperability function enables ATMAS to exchange messages with other external systems to implement information sharing, and it is recommended to include the followings:

a. Data synchronization with fallback ATMAS

Please refer to Chapter 3.2.9.

b. Messages exchange with Tower systems

The system is recommended to be able to exchange messages with the integrated tower system, A-SMGCS, and tower electronic flight strip system. The followings are the major exchanging messages:

➤ flight plan message

Providing synchronization information of flight plan messages between ATM system and tower system, including flight plans creation, modification, deletion, cancellation and flight plan life evolution, etc.

➤ SSR assignment message

Providing synchronization information of SSR allocation and release between ATM system and tower system.

➤ Runway operational state

Providing synchronization information of runway operational states between ATM system and tower system, including DEP, ARR CLOSE, and additional information such as inspection and construction temporarily, etc.

4.8 Cyber Threats and Mitigation

4.8.1 General Description

With the extensive deployment and closer interconnection of Commercial-Off-The-Shelf (COTS) Information and Communications Technology (ICT) Systems which is built on common standards rather than on the conventional proprietary equipment, Air Navigation Service Providers (ANSPs) have been facing increasing challenges in

protecting their critical infrastructure and manage potential risks arising from cyber security threats.

To address the growing concerns on cyber security threats, ICAO has extended its SARPs with Annex 17 on Security, with the supplement as in ICAO Doc 8973 “Aviation Security Manual” which sets out the aviation security requirements, including cyber security in ATMAS. In addition, ICAO published Doc 9985 “ATM Security Manual” setting out the principles and guidelines for protecting ATC system infrastructure from cyber attacks. States/Administrations are encouraged to pursue the appropriate level of compliance to the cyber security control requirements as stated in the ICAO documents and make collaborative efforts to effectively address cyber security threats. ICAO and other international organizations have been promoting the importance of cyber security in ATC systems via their website, such as ICAO’s Thematic Website on Cyber security (www.icao.int/cybersecurity) and CANSO’s website on Standard of Excellence in Cyber security.

4.8.2 Cyber Security Management

States/Administrations are encouraged to develop cyber security management, which adopts a proactive and systematic approach for protecting the increasing digitization of ATS against cyber threats, through the establishment of Cyber Security Manual, Cyber Security Handbook and User Account Management Policy. The above-mentioned documents should be developed in accordance with relevant provisions in ICAO Annex 17 and Doc 9985 to provide protection of the safety-critical ATMAS against cyber threats and interference. Key elements of enhanced controls on cyber security are as follows for reference:

a. Cyber Security Policy

States/Administrations should establish their own Cyber Security Policy to mitigate cyber threat. Dedicated committee or working group on cyber security with regular meetings is encouraged to set up for reviewing policies and steering the implementation of cyber security control measures throughout the whole life cycle of ATMAS.

b. Network Infrastructure Protection

Interoperation among ATMAS and other ATS systems for information exchange is inevitable. Proactive protection of the backbone data network of ATMAS is essential to ensure its operation. Multi-tier defence-in-depth scheme for external TCP/IP unicast communication to other systems, comprising network equipment, firewalls, Network Intrusion Detection (NIDS) or Network Prevention System (NIPS), is suggested to strengthen the protection of the network ATMAS against cyber threats from external connections. To further strengthen the above-mentioned scheme, data diode gateway could be utilized to leverage on unidirectional communication for the dissemination of data from ATMAS to other systems.

During the project implementation stage of ATMAS, Virtual Private Network (VPN) is often suggested by the system manufacturer to allow their personnel to assist in the installation and configuration of the system remotely. Since the system is not yet in operational use and is isolated from other operational ATC

systems, an external VPN connection to ATMAS is considered acceptable in general for facilitating the project implementation. States/Administrations should assess the cyber security risks involved in remote VPN access during the integration of data interfaces to other ATC systems and ensure that all the security risks have been mitigated to an acceptable level.

After the ATMAS is put into operational use, external VPN access by the system manufacturer is, in general, not recommended. If there are operational needs to keep the VPN access by system manufacturer, States/Administrations should assess the cyber security risks and safety risks involved and implemented all the necessary measures to mitigate the risks to an acceptable level.

c. User Account Management

To protect the ATMAS from the cyber security risk of access control, States/Administrations should establish a systematic and traceable process for the administration of user accounts applicable to authorized access to ATMAS.

d. System Development Life Cycle

To achieve the viability and sustainability of cyber security protection, the protection from cyber threats in mind throughout the system life cycle of the development of ATMAS is indispensable. States/Administrations could formulate a project procedures handbook, which includes cyber security requirements, to safeguard against cyber threats from an early concept and design stage of a project. Besides, Independent Network Security Risk Assessment (INSA) for ATMAS is encouraged to conduct at a different stage of the project cycle to assess the adequacy of the cyber security measures applied to the system development.

e. Removable Media Control

Removable media provides a common route for importing malicious content into an information system. To mitigate the potential risk posed by the use of removable devices or media in ATMAS, States/Administrations should consider refining their workflow to strengthen the security control, such that a removable media should be scanned for malicious content by the machine prior to uploading data to ATMAS.

f. Software Security Patch Management

Patching vulnerabilities for ATMAS is a key challenge maintaining the balance between security and performance. States/Administrations could set up a scheme to work closely with system manufacturers to evaluate system patches when considered appropriate.

g. Physical Security Measures

While cyber security measures are in place for dealing with cyber threats, States/Administrations should implement physical security measures to physically protect the infrastructure of ATMAS from physical threats. The physical security provision includes facility management, security guards,

CCTV surveillance, access control, physical lock, USB blocker, etc., from perimeter security down to console/rack level.

h. Response to Cyber Security Incidents

States/Administrations are encouraged to collaborate with the relevant local authority responsible for the investigation and prevention of cyber crime closely. A direct reporting mechanism is recommended to establish in order to seek swift assistance from the local authority for handling cyber security incidents. States/Administration is encouraged to seek relevant authority for an independent assessment of cyber security measures implemented on ATMAS. Periodic drill exercises should be arranged to upkeep staff awareness and the robustness of the reporting mechanism

5. System Transition

There are several scenarios in which ATMAS transition normally happens, ranging from minor to major changes, including:

- a. Major software and/or hardware upgrade, including operating system upgrade and important modules upgrade such as SDP or FDP to provide new or enhanced functionalities. These cases may influence the system stability, so it is recommended to take a transition to guarantee the operation safely.
- b. Overall system upgrade with new software and hardware equipment.

For a more complex transition that involves multiple stakeholders and equipment, change management, safety risk management, transition plan, rehearsal, and post-transition support are the key elements to ensure a smooth system transition.

5.1 Phases of System Transition

There are mainly four transition phases: transition preparation, transition rehearsal, system transition and post-transition operation.

- a. Transition preparation: the necessary preparation for transition in this phase, transition scheme, safety assessment, equipment preparation, staff training, an manual update shall be completed.
- b. Transition rehearsal: The main objective of this phase is to build confidence in the new changes and flag any possible issues before the actual transition. It can be achieved by running an online test of the new system during off-peak hours or in the backup system in parallel with the operational system. During the online test, the new system could be connected with external interfaces and systems progressively. The operational users and engineering staff will test the main functions and interfaces, and record necessary optimization to the system as well as the rehearsal procedure. The frequency and duration of rehearsal shall be adjusted according to the complexity of the system transition.
- c. System transition: In this phase, the new system will be put into operation. If the transition is complex with software and hardware upgrade, shadow operation is suggested, and the shadow operational period could last 1 or 2 weeks or even longer where appropriate. And according to the result of the shadow operation, the time point to start the transition shall be determined. If the transition fails, a decision on whether to repeat or roll back needs to be made.
- d. Observing operation: In this phase, the new system operates on line, and an observation period of one month or more is suggested, depending on the complexity of the changes.

5.2 Transition Preparation

5.2.1 Transition Scheme

A complete transition scheme is necessary for a successful transition. Depending on the scale of the transition, the transition scheme is suggested to contain the followings:

- a. The preliminary work to be finished, including:
 - Review of acceptance testing results and equipment preparation.
 - Review of the adequacy of change management and safety risk management.
 - Review of training, including the competence of operational and engineering staff.
 - Review of the change in ATC Procedures and update the operation manual.
 - Other relevant work required.
- b. Transition steps, procedures, and key points.
- c. Checklist: used to check the system transition operation and verify system functions and performance during transition rehearsal and system transition.
- d. Decision mechanism: transition institution shall be established to determine on the transitional key point.
- e. Contingency plan: used to cope with the emergency situations and include the decision mechanism about roll back or transition delay, roll back plan, and the emergency support team.

5.2.2 Scheme Evaluation

The scheme evaluation is necessary and proposed to include scheme feasibility, scheme completeness, scheme presumption, equipment and staff preparation, the stability of the new system, and the solutions to bugs discovered during the on-site test. According to all these elements, some improved suggestions should be raised to make the scheme more perfect. After the evaluation, recheck should be made to ensure the implementation of the suggestions.

5.2.3 System Deployment

To ensure the system rehearsal and transition smoothly, the technical staff should validate the new software version on the test platform to ensure the new version can work well. And then, the system maintenance department should deploy the new software and hardware in advance. Making sure all the new software and hardware deployed in the system will shorten the time of transition sufficiently.

5.2.4 Table Pre-rehearsal

Table-top exercise refers to the process in which the participants use maps, sand tables, flow charts, and other auxiliary means to interactively discuss and deduce the transition steps and emergency decision-making in the transition scheme.

Table-top exercise is recommended to ensure the feasibility of system switch steps, the smoothness of cooperation, the completeness of checklist, and the rationality of time arrangement.

5.2.5 Other Preparations

The operational and engineering manual should be updated, including system information, technical manual, notification process, and emergency plan.

Before the rehearsal, the system maintenance department should train staff about the transition scheme and the updated manual to help them understand the system transition, collaboration matters among departments and system new functions.

5.3 System Rehearsal/Pre-Transition Verification

The transition scheme, including the detailed transition procedure and steps, should be made familiar to the team through training activities prior to the system transition. Depending on the complexity, several system rehearsals are suggested to be performed during the off-peak hours. The purpose of the system rehearsal is to verify the transition procedure as well as to validate the functionality, reliability, and stability of the new system in a real operational environment.

5.3.1 System Switch Steps Validation

The transition procedures are recommended to be validated according to the overall transition rehearsal scheme. The procedure to be validated includes at least the following: system switching steps, operating contents, transition team, and reasonability allocation, notification and reporting process. A checklist is suggested to be developed and optimized according to the result of each rehearsal. The optimization should be verified at the next rehearsal.

During the rehearsal, the time spent on each step is advised to be verified and be used as a reference to support the decision making during the formal transition.

5.3.2 System Functions and External Interfaces Validation

The system functions and external interfaces are suggested to be tested and to ensure that they are functional as intended during the rehearsal. To ensure a smooth transition, the problems identified during the transition should be recorded in detail and corrected with the support of the SP.

5.4 System Transition

At the end of the above preparation activities, the transition management organization is suggested to decide to approve the date and time of the formal transition, based on the transition scheme evaluation report, the transition preparation status, and the result of the transition rehearsals.

For major system replacement or overall system upgrade transition, the shadow period is recommended to put the new system into operation during an off-peak time, to verify the system performance in a real operational environment, and to allow staff to gain familiarity and confidence in operating the new system. The duration of the shadow period is determined by controllers. 1~2 weeks shadow period is suggested to make every shift familiar with the new system. Appropriate rostering of staff is required such that all staff will be given the opportunity to gain experience in operating the new system.

Finally, the transition is recommended to be performed based on the pre-defined procedure at the pre-defined transition time. The new system should be put into operational use after the verification of the functioning of the system is confirmed following its transition.

However, suppose there are blocking or critical issues, such as issues affecting safe operation occurring during the transition. In that case, decisions should be made according to the decision making strategy defined in the transition scheme, which may result in rollback or delay of the transition.

5.5 Post-Transition Operation

The post-transition operation phase is suggested as the run-in period of the system, which preferably requires additional staffing from the MSP as well as SP to resolve teething issues. The issues identified during this phase should be timely analyzed, corrected, and reviewed. In addition, the maintenance experience of the new changes will be accumulated.

The duration of the post-transition operation phase is recommended to be one month or longer. A formal assessment is suggested to be performed at the end of this phase. The assessment is proposed to include:

- a. Issues reported during the observation period.
- b. The cause analysis and possibly the avoidance and corrective methods of the issues.
- c. Recommendations for future operation, matters-needs-attention, etc.

The system will enter the stable operation phase after the observation period.

6. System Maintenance

The ATMAS goes to the system maintenance phase after being put into operation. System maintenance is necessary for the entire service life of the system. Critical functions and equipment should normally work even as the environment changes through planned and organized maintenance. The purpose of system maintenance is to guarantee stable and continuous operation and to improve the performance of the system.

6.1 System Maintenance Participants

To handle the maintenance of complex and safety-critical ATMAS, robust and systematic maintenance management, and practice should be set up with close cooperation among system suppliers, Maintenance Service Provider (MSP), and the Air Navigation Service Provider (ANSP) to ensure the operation of the system.

Under the maintenance framework for ATMAS, the system supplier, MSP, and ANSP form a close coordination trio in operating and supporting the maintenance framework.

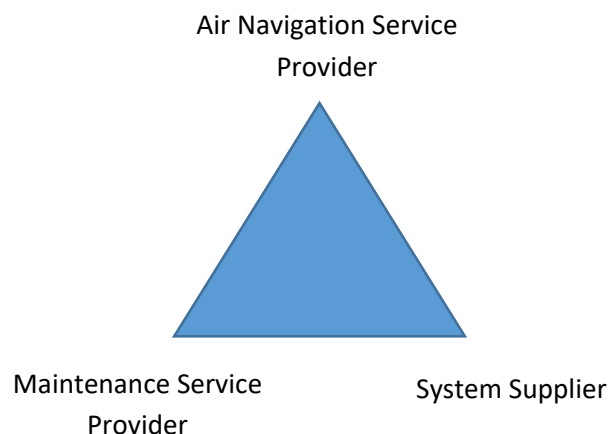


Figure7.1-1: Trio for Maintenance Framework

6.1.1 System Supplier

The design of system plays a critical role in the ease of maintenance during the operation stage of the system. Before system commissioning, the system supplier, as the entity with the most comprehensive know-how on the system, should provide sufficient maintenance documentation and training to ANSP and MSP, including complete information for proper installation, setup, use, operation, support, and maintenance of the system.

The system supplier should provide documentation to the ANSP and MSP for aiding the use, application, and maintenance of the system and individual equipment, which should include:

- a. Operation handbooks and user manuals for operating procedures and system functionalities for use by controllers, supervisors, assistants, and support specialists.
- b. Technical literature for the full technical description of configuration and operation in the system as well as full details of each system component, block diagrams with data flow, mechanic and wiring schematic diagrams, as-built drawings, etc.
- c. Service and maintenance manuals, including system setup, optimization and parameterization, preventive maintenance procedures (system checking and rebooting, calibration, cleaning, housekeeping, etc.) with recommended frequencies, and troubleshooting procedures in hardware and software (recommended solution and flow chart to identified issues, handling of alarms and error messages, etc.).

All documentation should be reviewed and endorsed by the relevant authority prior to use.

The system supplier should prepare training plans and training course materials for ANSP and MSP for review with sufficient time prior to critical milestones, such as commencement of design review, factory/site acceptance tests, and ATC operational train-the-trainer course. ANSP, in coordination with MSP, should set out the required training topics, which should be specific to different user groups, in the system contract.

Subject to actual needs, after ANSP and MSP have built up their own training capability, on-site maintenance review and assessment on MSP should be conducted by the system supplier after commissioning on a regular basis, with more frequent training/assessments during the start-up and run-in period after commissioning.

As ATMAS is a complex system, it is unavoidable that unexpected technical issues might emerge, especially teething issues during the early stage of operation. As such, the system supplier should be required to respond to requests from ANSP or MSP to provide timely assistance in dealing with and rectifying all faults or deficiencies in software and hardware within pre-defined response time according to the criticality of such faults or deficiencies as specified in the contract. Repeated faults should be handled and investigated with high priority by the system supplier to identify the root cause and implement corrective measures.

Since technology is changing rapidly, some system components might become obsolete and become difficult to source in the market. The system supplier should provide a list of obsolete equipment and its replacement models on a regular basis, and the replacement model should be evaluated on-site for its compatibility prior to use as a spare for operation.

The performance of the system supplier has to be regularly reviewed in suitable forums, such as performance review meetings in conjunction with ANSP and MSP representatives.

The system supplier could consider forming user groups to allow sharing of users' experiences and gather feedbacks. The system supplier should facilitate regular hosting of user group meetings.

6.1.2 Maintenance Service Provider

The engagement of an MSP to perform frontline maintenance under the supervision of ANSP is a practical solution in leveraging skill sets and the latest technology available in private sector in order to facilitate the provision of reliable services with cost benefit.

Under the regime of compliance to all applicable ordinances and regulations, Safety Management System and Air Traffic Safety Electronics Personnel (ATSEP), the maintenance services provided by MSP should include watch-keeping of equipment, preventive/corrective maintenance, system/equipment minor modification/replacement works, staff training, and procurement of spares and test equipment/ tools. Support services such as record-keeping on maintenance activities, preparation of statistics and reports and inventory control, etc., could be provided as part of the package from MSP.

MSP needs to perform maintenance according to the system supplier's established procedures at recommended intervals, including health checks on the system, servers, equipment and workstations, critical data backup, and log capture/review for hardware, software, user management, and other activities, system parameters and user preference checks and backup, regular clean-up, and reboots of hardware including servers and workstations, etc. Proactive system housekeeping procedures adopting industry best practices with the recommendation from system supplier and expertise from MSP, together with close monitoring of system healthiness/system resources and housekeeping of servers/workstations on a regular basis to upkeep the system performance, should be in place.

There could be cases that due to the local specific environment/operational status of the ATMAS, it would require extra steps or more frequent maintenance, e.g., more frequent clean-up/reboot of servers and workstations, on top of recommended maintenance procedures by system supplier. MSP, who looks after the system day-by-day and is familiar with local environment, would contribute their expertise in adapting the maintenance procedures to fit into the local needs after consulting the system supplier.

In addition, like any critical system running on a round-the-clock basis, ATMAS has no exception that it might encounter system fault where immediate attention from MSP is required. For example, a server breakdown after a software bug is hit with no or little pre-alerts. It is important that MSP has geared up with a full deck of operational instructions for their watch-keeping staff to handle all sorts of foreseeable system scenarios with proper initial and refresher training/drills on such scenarios. The build-up of know-how and experience for MSP in dealing with urgent scenarios is crucial to smooth operations of the ATMAS.

Similar to system suppliers, the service level of performance of MSP has to be constantly monitored to meet the target levels set out in the contract and regularly reviewed in suitable forums, such as operations & maintenance review meetings in conjunction with ANSP representatives to ensure maintenance provisions could meet the service needs.

6.1.3 Air Navigation Service Provider

As the party to govern maintenance service performance by MSP and system supplier through various means discussed above, ANSP has to ensure the necessary support and resources to be provided to MSP and system supplier for fulfilling or even exceeding. The baseline maintenance requirements are set out in the contracts with these parties. Payment deduction might be incorporated into the contract to handle cases where performance does not meet requirements, but it might bear impacts on maintaining a good relationship with MSP or system supplier.

ANSP has to ensure the services provided by MSP and system suppliers are in compliance with ICAO standards and international best practices. ANSP is encouraged to share experience and best practices gained from ICAO and international meetings/symposia/ seminars, as well as overseas facts-finding visits, with MSP and/or system suppliers with a view to enhancing the maintenance regime.

To allow ATC professionals to perform their work safely and satisfactorily, it is highly desirable for ANSP's engineering professionals to understand the operational needs such that the ATMAS could fully support their work. As such, constant communications with ATC professionals in addressing their needs via suitable steering forums and communication channels would be critical to the smooth operations of ATMAS. Following the system commissioning, a technical team comprising ANSP engineering professionals, system supplier, and MSP, could be established with ATC professionals to oversee system performance and deployment of new software builds and system data updates to ensure smooth operation of the ATMAS.

6.2 Resources Requirement

Necessary resources are mandatory for system maintenance, and the main considerations are as follows:

6.2.1 Staffing

MSP should ensure sufficient staff is employed to form a maintenance team and provide 24-hour operation and maintenance.

Before stepping into the system maintenance phase, MSP and ANSP should ensure the personnel is fully trained by the SP or certified trainers. This ensures that the personnel involved in the maintenance work grasp knowledge and skills related to the system. It is also recommended to arrange on-site training by SP for MSP and ANSP after system installation. Before the training, the training plans and training course materials should be fully reviewed by ANSP/ MSP in accordance with contract requirements and define training topics for different users.

Before the system is put into operation, MSP and ANSP are recommended to send personnel to work in different phases for technical reserves in advance and enhance their comprehension and familiarity with the system, which will be conducive to the subsequent maintenance work:

- a. System design phase

MSP and ANSP are recommended to send personnel to participate in the design of the system to track the project development progress in SP factory, check the rationality and applicability of the design of each functional module of the system and put forward suggestions, and review technical documentation at the milestone, including the consistency of requirements, product design, handbooks, and acceptance test book.

b. Factory acceptance test phase

MSP and ANSP shall send personnel to participate in factory acceptance test in accordance with the contract requirement. MSP and ANSP personnel shall review the acceptance test books provided by SP in advance. The acceptance test shall be executed according to the approved test book in the test environment, such as platform, signal, instrument, etc., prepared by SP, and the result shall be recorded in the report.

c. Installation phase

After the work of on-site equipment installation starts, MSP should send personnel to participate in the whole process of hardware installation, software debugging, on-site acceptance tests, flight inspection, etc. At this stage, personnel should be well familiar with important information such as equipment installation location, cabling, signal routing, position layout, label, signs, etc. They also need to learn software debugging and testing methods, and master the knowledge of system's functions and performance during on-site testing and flight inspection.

Besides above all, MSP and ANSP should set up their own maintenance personnel training systems, maintenance personnel access mechanism, and regular assessment of personnel skills to ensure that qualified personnel can perform the operation, maintenance, and management of the system.

6.2.2 Documents

Before the start of the system maintenance phase, MSP and ANSP should make sure necessary documents are in place to run the system. The documents should include at least the following:

- a. System Design Specification: a set of technical documentation including system architecture, interface control documents, function module principle, etc.
- b. Operational manual: an instruction manual that describes the function, performance, and user interface of the system software in detail so that the maintenance can understand how to use the operate the system.
- c. Maintenance Manual: the service and maintenance manual includes system installation, parameters setting, maintenance suggestions, as well as troubleshooting procedures in hardware and software (it is recommended to provide a flow chart to locate and solve the problems and a method to identify

the alarm and error, etc.)

- d. User guides documentation: detailed description and operation guide of HMI for controllers, FIO, Flow.
- e. Installation documentation: including details of each component of the system, cabinet layout, figure with data flow, mechanical and wiring schematic diagram, as-built drawing, etc.
- f. Training documentation: including training materials or documents related to factory and on-site training.
- g. Testing documentation: including achievement of acceptance criteria and identification of outstanding issues
- h. Emergency response process documentation: in the event of sudden equipment failure, effective countermeasures can be taken in time to minimize the impact of equipment failure on air traffic control operations.

Besides, MSP and ANSP should work out their working procedures, maintenance plans, and contingency plan for unning the system.

All documents should be reviewed and approved before application which should be updated continuously to keep the accuracy according to the changes in system behavior during the long-term operation.

6.2.3 Maintenance Tools

MSP and ANSP are recommended to be equipped with instruments and maintenance tools required for system maintenance, for example, a simulator used to simulate track and message for system test, a software management tool for installation, rollback, and backup operation to software patch and release. Training for maintenance personnel shall cover the use of instruments, maintenance tools, and simulators by MSP and SP.

6.2.4 Spare parts

Sufficient hardware spare parts shall be reserved for the ATMAS, including servers, workstations, monitors, network equipment, etc. The percentage of spare parts is related to the scale of the system. The mechanism of spare parts management should be set up, including periodically testing and checking the reserve status to make sure that the spare parts are sufficient and available.

Since it is very common that computer hardware will be updated frequently, ANSP/MSP should review the list of hardware and confirm with the SP a list of obsolete hardware and replacement solutions regularly. The replacement hardware should be reserved as spare parts after finishing the site compatibility assessment.

If conditions allow, ATMAS Test and Validate System (TVS) is recommended to be deployed for supporting new software testing, system parameter adjustment, personnel training, etc.

6.3 Maintenance Content

System maintenance is recommended to include the following at least:

6.3.1 Periodic maintenance

Periodic maintenance including daily, weekly and monthly, etc. Which maintenance matters should be worked out according to the real operational requirements. It is recommended to cover the followings:

- a. Check the running status of the system software, dual nodes redundancy.
- b. Check the running status and health of the system hardware, including network load and the usage of resources such as CPU, memory, and disk of servers, workstations, and network devices. Please refer to section 4.5.2 for the inspection standards.
- c. Check the validation of external data, including surveillance data, AFTN, AIDC, meteorological data, GNSS, and the status of data interaction with the external system, if any.
- d. Check the integrity of the recorded data to prevent the data lost.
- e. Check the status of basic function on bypass server.
- f. Perform active/standby switch between the redundant servers to ensure both servers can operate normally.
- g. Backup critical files and data periodically, including the system configuration parameters, database, log, etc.
- h. Manually clean and reboot the server and workstation regularly.
- i. Check the physical system operating environment regularly, including temperature, humidity, equipment grounding, electromagnetic environment, etc.
- j. Switch the backup system to operational mode regularly to achieve a balanced use for both main and backup systems.

6.3.2 Troubleshooting

MSP should promptly execute troubleshooting, correct system errors, and ensure that the system work normally by replacing components, updating software or parameter configuration, and other methods.

SP should respond in time to the requirements of MSP or ANSP after a failure occurs and assist MSP in handling and correcting the failure within the predetermined response time according to the severity.

MSP needs to record all the system problems in different kinds and problem-solving processes, and collect necessary system logs for analysis.

When a problem is judged as a software defect, MSP needs to register and track the problem. It is recommended to use a fixed PCRs form to register the system software problems, including supplier name, site location, software version number, failure time, failure content description, user investigation of relevant logs, the severity of the problem, etc.

After being confirmed by ANSP, MSP sends the PCRs to SP in time for problem analysis and software repair.

According to the information in PCRs, SP establishes the problem database, checks software code, locates and repairs software defects, and provides problem analysis reports.

The software defect repair plan is discussed by SP, MSP, and ANSP, and they jointly determine the delivery and implementation schedule of the software patch.

6.3.3 Software Version and Requirement Management

After the software is approved in site acceptance and put into operation, the software version and requirement management are managed by SP, MSP, and ANSP together throughout the service life of the system.

6.3.3.1 Baselines Establishment

Usually, SP will select a stable ATMAS software version defined as a Baseline, before SP develops a set of ATMAS based on the requirement of customers. The Baselines are defined for further software life cycle process activity and allow reference to, control of, and traceability between configuration items.

Baselines establishment is recommended to consider the factors as follows:

- a. Baseline should be established for each set of ATMAS.
- b. ATMAS Baseline is a stable software version that has been approved.
- c. Once a Baseline is established, it should be protected from change.
- d. In the service life of the system, the Baseline should have the check code and check method of the corresponding program to ensure the traceability consistency, and uniqueness of the program.

After the baseline version of the automation system is established, the customization of the automation system functions need to be fully discussed, researched, and agreed upon by SP, MSP, and ANSP. Then the SP carries out systematic research and development, and finally delivers the system software to users after passing factory acceptance and site acceptance.

6.3.3.2 System Requirement Management and Software Upgrade

The system function requirements usually come from the change of ATC procedures, the application of new technologies, etc., and the new functions are put into operation through software version upgrades.

ANSP may formulate a standard software requirements library according to operational needs, regularly maintain and update the requirements library, and guide the upgrading of software versions and the construction of new systems.

MSP is responsible for recording function requirements, analyzing and evaluating the description and scheme of the requirements, and submitting them to SP for development after being verified by ANSP.

SP completes the system software change and delivers it to MSP after passing the self-test, attaching the analysis of the impact scope of the software change.

MSP need to carry out functional improvement test and system stability test for software change. After ensuring that there is no defect, MSP shall jointly agree with ANSP on the effective time of software upgrade and implement the upgrade.

During the implementation of the software upgrade, MSP is recommended to backup the operating software. If there is any problem in the upgrading, MSP need to roll back the software to the previous version in time.

Note: If SP is responsible for the maintenance of system software throughout the service life of the system, the specific software maintenance contents may be defined in the contract which is agreed upon by all related parties.

Appendix A

ATMAS IGD Request for Change Form

RFC Nr:	

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/FA/X/E-MAIL:			
6. CONSULTATION RESPONSE DUE BY DATE:			
	Organization	Name	Agree/Disagree Date
7. ACTION REQUIRE :			
8. AIGD EDITOR		DATE REC'D :	
9. FEEDBACK PASSED		DATE :	

Appendix B

Table 3.2.10-1A Flight Specific Flight Data

Aircraft ID	Traversed Sector/s	Controlled Airspace	Flight Rule	Flight Type	No. of Danger Area Infringements	No. of Uplink Messages		No. of Downlink Messages		No. of Delivery Timeouts	
						Rejected	Accepted	Rejected	Accepted	Uplink	Downlink

[Selected Time Period]

Aircraft ID	No. of AIDC Messages		No. of AIDC Messages	
	Rejected	Accepted	Transmitted	Received

Table 3.2.10-1B Collective Flight Data

Day/Week/Month	Total No. of Flights	Airspace Sector				No. of Danger Area Infringements	No. of Uplink Messages		No. of Downlink Messages		No. of Delivery Timeouts	
		N	W	E	S		Rejected	Accepted	Rejected	Accepted	Uplink	Downlink

Day/Week/Month	Controlled Airspace				Flight Rule				Flight Type				
	ARR	DEP	OVF	DOM	I	V	Y	Z	S	N	G	M	X

Table 3.2.10-2 Flight Specific Surveillance Data

[Selected Time Period]

Aircraft ID	Surveillance Track Type				Source of Surveillance Track				Quality of Surveillance Track			
	Secondary	Mode S	Multilat	ADS-B	Secondary	Mode S	Multilat	ADS-B	Secondary	Mode S	Multilat	ADS-B
	o	o	x	o	1	2	-	2	Coast	Normal	-	High

Appendix C

Performance of Surveillance Data Processing in RSUR

RSUR Specifications define technical performance requirements of ATS surveillance systems used in support of a particular ATS application in a given airspace.

The RSUR-5NMSEP_ER_Tier-C specification are applicable to the delivery of surveillance data at the output of a surveillance system that is used to support 5 NM Separation service in en-route environment as described in PANS ATM (Doc 4444) section 8.7.3 in a Tier C environment.

Table 3-1: RSUR_5NMSEP_ER_TIER-C

RSUR specification 5NM-SEP_ER_TIER-C								
DATA	Coherence		Integrity			Time		Reliability
	Update Interval UI	Probability of Update	Core Error	Tail error	Integrity	Age	Delay	
2D Horizontal Position (HP)	DAT _{UI} ≤ 12s	PoU ≥ 97%	HPE _{RMS} < 825m or HPE _{95%} < 1430m	RNBE _{LB} = 2714m RNBE _{UP} = 3644m	HP _{INT}	HP _{MDA} = 36.3s	-	-
Pressure Altitude (PA)			-	-	PA _{INT} < 0.1%	PA _{MDA} = 30s	-	-
Mode A code Identity (ID)			-	-	ID _{INT} < 0.1%	-	ID _{MUD} = 48s	-
Flight Status (emergency, SPI = FS)	-	-	-	-	-	-	FS _{MUD} = 24.2s	-
Time of applicability	With HP	-	-	-	-	-	-	-
Service	In defined OCV HP _{RTD} < 0.3s		FGT _{DEN} < 0.1% SRV _{INT} < 10 ⁻⁵ per report					SRV _{CNT} = 0.999 /hour

The RSUR-5NMSEP_ER_Tier-B specification are applicable to the delivery of surveillance data at the output of a surveillance system that is used to support 5 NM Separation service as described in PANS ATM in en-route airspace (ICAO Doc4444) section 8.7.3 in a Tier B environment .

Table 3-2: RSUR-5NM SEP TIER B

RSUR specification 5NM-SEP_ER_TIER-B								
DATA	Coherence		Integrity			Time		Reliability
	Update Interval UI	Probability of Update	Core Error	Tail error	Integrity	Age	Delay	
2D Horizontal Position (HP)	DAT _{UI} ≤ 8s	PoU ≥ 97%	HPE _{RMS} < 540m or HPE _{95%} < 940m	RNBE _{LB} = 1776m RNBE _{UB} = 2384m	HP _{INT}	HP _{MDA} = 24s	-	-
Pressure Altitude (PA)			-	-	PA _{INT} < 0.1%	PA _{MDA} = 30s	-	-
Mode A code Identity (ID)			-	-	ID _{INT} < 0.1%	-	ID _{MUD} = 32s	-
Flight Status (emergency status, SPI = FS)	-	-	-	-	-	-	FS _{MUD} = 16s	-
Time of applicability	With HP	-	-	-	-	-	-	-
Horizontal Velocity			VEL _{RMS} =					
Vertical rate								
Flight status ground/air-borne							FS _{MUD} = 16s	
Aircraft Identification							ID _{MUD} = 32s	
ACAS capability					CAP _{INT} < 10 ⁻⁵			
ADS-B version number					CAP _{INT} < 10 ⁻⁵			
Service	In defined OCV HP _{RTD} < 0.3s		FGT _{BEN} < 0.005% SRV _{INT} < 10 ⁻⁵ per report					SRV _{CNT} = 0.9999 /hour

The RSUR-5NMSEP_ER_Tier- A specification are applicable to the delivery of surveillance data at the output of a surveillance system that is used to support 5 NM Separation service as described in PANS ATM (ICAO Doc4444) in en-route airspace section 8.7.3 in a Tier A environment.

Table 3-3: RSUR_5NMSEP_ER_TIER-A

DATA	RSUR specification 5NM-SEP_ER_TIER-A							
	Coherence		Integrity			Time		Reliability
	Update Interval UI	Probability of Update	Core Error	Tail error	Integrity	Age	Delay	
2D Horizontal Position (HP)	DAT _{UI} ≤ 5s	PoU ≥ 97%	HPE _{RMS} < 230m or HPE _{95%} < 400m	RNBE _{LB} = 1262m RNBE _{UP} = 1695m	HP _{INT}	HP _{MDA} = 15s	-	-
Pressure Altitude (PA)			-	-	PA _{INT} < 0.1%	PA _{MDA} = 30s	-	-
Mode A code Identity (ID)			-	-	ID _{INT} < 0.1%	-	ID _{MUD} = 32s	-
Flight Status (emergency status, SPI = FS)	-	-	-	-	-	-	FS _{MUD} = 10s	-
Time of applicability	With HP	-	-	-	-	-	-	-
Horizontal Velocity			HVE _{RMS} < ?					
Vertical rate			VRE _{RMS} < ?					
Flight status ground/air-borne							FS _{MUD} = 10s	
Aircraft Identification							ID _{MUD} = 32s	
ACAS capability					CAP _{INT} < 10 ⁻⁵			
ADS-B version number					CAP _{INT} < 10 ⁻⁵			
ADS-B in capability					CAP _{INT} < 10 ⁻⁵			
Data-link capability					CAP _{INT} < 10 ⁻⁵			
Resolution Advisory status						X _{MDA} < DAT _{UI} + 2s		
Barometric pressure setting						X _{MDA} < DAT _{UI} + 2s		
Expanded State vector (2.3.3.5)						X _{MDA} < DAT _{UI} + 2s		
Service	In defined OC'V HP _{RTD} < 0.3s		FGT _{DEN} < 0.005% SRV _{INT} < 10 ⁻⁵ per report					SRV _{CNT} = 0.99999/h

The RSUR-5NMSEP_ER_Tier-C specification are applicable to the delivery of surveillance data at the output of a surveillance system that is used to support 3 NM separation service in TMA environment as described in PANS ATM (Doc 4444) section 8.7.3 in a Tier C environment.

Table 3-4: RSUR_3NMSEP_TMA_TIER-C

RSUR specification 3NM-SEP_TMA_TIER-C								
DATA	Coherence		Integrity			Time		Reliability
	Update Interval UI	Probability of Update	Core Error	Tail error	Integrity	Age	Delay	
2D Horizontal Position (HP)	$DATA_{UI} \leq 5s$	$POU \geq 97\%$	$HPE_{RMS} < 450m$ or $HPE_{95\%} < 780m$	$RNBE_{LB} = 1478m$ $RNBE_{UI} = 1985m$	HP_{INT}	$HP_{MDA} = 15s$	-	-
Pressure Altitude (PA)			-	-	$PA_{INT} < 0.1\%$	$PA_{MDA} = 30s$	-	-
Mode A code Identity (ID)			-	-	$ID_{INT} < 0.1\%$	-	$ID_{MUD} = 20s$	-
Flight Status (emergency, SPI = FS)	-	-	-	-	-	-	$FS_{MUD} = 15s$	-
Time of applicability	With HP	-	-	-	-	-	-	-
Service	In defined OCV $HP_{RTD} < 0.3s$		$FGT_{DEN} < 0.1\%$ $SRV_{INT} < 10^{-5}$ per report					$SRV_{CNT} = 0.999 / hour$

The RSUR Specification defines the performance of ATS surveillance systems used in the provision of Terminal Control Area TMA (see definition in PANS-ATM) (Doc4444) in Terminal Area section 8.7.3 in a Tier B environment.

Table 3-5: RSUR 3NMSEP_TMA_TIER-B

RSUR specification 5NM-SEP_TMA_TIER-B								
DATA	Coherence		Integrity			Time		Reliability
	Update Interval UI	Probability of Update	Core Error	Tail error	Integrity	Age	Delay	
2D Horizontal Position (HP)	DAT _{UI} ≤ 5s	PoU ≥ 97%	HPE _{RMS} < 300m or HPE _{95%} < 520m (556m ADS-B)	RNBE _{LB} = 987m RNBE _{UP} = 1326m	HP _{INT}	HP _{MDA} = 15s	-	-
Pressure Altitude (PA)			-	-	PA _{INT} < 0.1%	PA _{MDA} = 30s	-	-
Mode A code Identity (ID)			-	-	ID _{INT} < 0.1%	-	ID _{MUD} = 20s	-
Flight Status (emergency status, SPI = FS)	-	-	-	-	-	-	FS _{MUD} = 15s	-
Time of applicability	With HP	-	-	-	-	-	-	-
Horizontal Velocity (VEL)			VEL _{RMS} =					
Vertical rate (VR)								
Flight status ground/air-borne							FS _{MUD} = 15s	
Aircraft Identification							ID _{MUD} = 20s	
ACAS capability					CAP _{INT} < 10 ⁻⁵			
ADS-B version number					CAP _{INT} < 10 ⁻⁵			
Service	In defined OCV HP _{RTD} < 0.3s		FGT _{DEN} < 0.004% SRV _{INT} < 10 ⁻⁵ per report					SRV _{CNT} = 0.9999 /hour

The RSUR Specification defines the performance of ATS surveillance systems used in the provision of Terminal Control Area TMA (see definition in PANS-ATM) (Doc4444) in Terminal Area section 8.7.3 in a Tier A environment.

Table 3-6: RSUR 3NM-SEP_TMA_TIER-A

RSUR specification 5NM-SEP_TMA_TIER-A								
DATA	Coherence		Integrity			Time		Reliability
	Update Interval UI	Probability of Update	Core Error	Tail error	Integrity	Age	Delay	
2D Horizontal Position (HP)	DAT _{UI} ≤ 5s	PoU ≥ 97%	HPE _{RMS} < 150m or HPE _{95%} < 260m	RNBE _{LB} = 1736m RNBE _{UP} = 988m	HP _{INT}	HP _{MDA} = 15s	-	-
Pressure Altitude (PA)			-	-	PA _{INT} < 0.1%	PA _{MDA} = 30s	-	-
Mode A code Identity (ID)			-	-	ID _{INT} < 0.1%	-	ID _{MUD} = 20s	-
Flight Status (emergency status, SPI = FS)	-	-	-	-	-	-	FS _{MUD} = 10s	-
Time of applicability	With HP	-	-	-	-	-	-	-
Horizontal Velocity			HVE _{RMS} < ?					
Vertical rate			VRE _{RMS} < ?					
Flight status ground/airborne							FS _{MUD} = 10s	
Aircraft Identification							ID _{MUD} = 20s	
ACAS capability					CAP _{INT} < 10 ⁻⁵			
ADS-B version number					CAP _{INT} < 10 ⁻⁵			
ADS-B in capability					CAP _{INT} < 10 ⁻⁵			
Data-link capability					CAP _{INT} < 10 ⁻⁵			
Resolution Advisory status						X _{MDA} < DAT _{UI} + 2s		
Barometric pressure setting						X _{MDA} < DAT _{UI} + 2s		
Expanded State vector (2.3.3.5)						X _{MDA} < DAT _{UI} + 2s		
Service	In defined OCV HP _{RTD} < 0.3s		FGT _{DES} < 0.005% SRV _{INT} < 10 ⁻⁵ per report					SRV _{CNT} = 0.99999/h

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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

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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)	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

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	BHUTAN		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	BRUNEI DARUSSALAM		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	CAMBODIA		
ADM	Mr. Neang To (2022.09.08)	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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CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
URG	Mr. Heng Mengkong (2022.09.08)	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	Lau Kin Hei, Arthur	Electronics Engineer Civil Aviation Department	Tel: +852 2910 6519 Fax: +852 2845 7160 E-mail: cns_icao@cad.gov.hk
URG	Hui Man Ho	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
	MACAO, CHINA		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:

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CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
	FIJI		
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	FRANCE		
	FRENCH POLYNESIA		
ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
	NEW CALEDONIA		
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ADM			Tel: Fax: E-mail:

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ADM			Tel: Fax: E-mail:
URG			Tel: Fax: E-mail:
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ADM			Tel: Fax: E-mail:
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	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		

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CAT	STATE/ NAME OF CONTACT	TITLE/ORGANIZATION	TEL/ FAX / E-MAIL
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ADM			Tel: Fax: E-mail:

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	PAPUA NEW GUINEA		
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	TUVALU		
ADM			Tel: Fax: E-mail:
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URG			Tel: Fax: E-mail:

ACTION ITEMS OF CNS SG/26					
Action Item	Subject	Status / Target Date	Action Party	Status	Remarks / follow-up
26-1	Submit a joint CNS-ATM Working Paper to discuss and highlight the issue on alerts of AIDC messaging failure (<i>details in WP/32 Air Traffic Management and Airspace Safety Monitoring Outcomes of CNS SG/26</i>)	ATMAS TF/4	ICAO Secretariat		
26-2	Provide technical support to Sri Lanka for CRV Implementation	CNS SG/27	Sri Lanka, CRV OG Chairs, PCCWG, ICAO Secretariat		
26-3	Ensure SWIM TF and ACSICG experts are involved in the FF-ICE workshop/webinar/seminar to be held by ATMAS TF.	Next FF-ICE workshop/webinar /seminar	ICAO Secretariat		
26-4	State Letter for encouraging States to coordinate with ICAO APAC Regional Office before assigning frequencies for aeronautical services in frequency bands of 190-526.5 kHz, 108-117.975 MHz, 960 – 1215 MHz and 117.975 to 137 MHz that may affect the use of aeronautical frequencies in other States.	CNS SG/27	ICAO Secretariat		
26-5	Review and propose revise APAC Navigation Strategy, if required.	CNS SG/27	APAC Member States, ICAO Secretariat		
26-6	Organize a webinar/workshop on Inconsistent ICAO Aircraft Address and Target Identification between Surveillance Data and Flight Plan	CNS SG/27	Hong Kong China, IATA, ICAO Secretariat		
26-7	Prepare and share the State Letter to all APAC Member States to provide their comments on proposed ICAO ATSEP human factor guidance material.	CNS SG/27	ICAO Secretariat		
26-8	Share the proposition to identify and incorporate the relevant ASBU modules in Doc 10057 - Manual on Air Traffic Safety Electronics Personnel Competency-based Training and Assessment to the relevant HQ expert group	CNS SG/27	ICAO Secretariat		

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List of Participants

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WORKING PAPERS			
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WP/02	2	Outcomes of APANPIRG/32, APANPIRG/32 Midyear Review and 9 th PIRG-RASG Regional Coordination Meeting on CNS	Secretariat
WP/03	2	Updates on CNS SG/25 and APANPIRG/32 Conclusions/Decisions and Action Items	Secretariat
WP/04	2	Relevant Action Items of 57 th Conference of Directors General of Civil Aviation	Secretariat
WP/05	3.1	Review Report of the Ninth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/9)	Secretariat
WP/06	3.2	AMHS Readiness Status for Supporting IWXXM Traffic of the States/Administrations	Secretariat
WP/07	4.1	Review Report of the Sixth Meeting of System Wide Information Management Task Force (SWIM TF/6)	Secretariat
WP/08	5.2	Review Report of the Sixth Meeting of Spectrum Review Working Group (SRWG/6)	Secretariat
WP/09	5.3	Potential Impacts from 5G Implementation on Aircraft Radio Altimeters – Outcomes in Relevant Meetings and Regional Updates	Secretariat
WP/10	6.1	Review Report of the Ninth Meeting of Performance Based Navigation Implementation Coordination Group (PBNICG/9)	Secretariat
WP/11	6.2	Review of Report of the Fourth Meeting of GBAS/SBAS Implementation Task Force (GBAS/SBAS ITF/4)	Secretariat
WP/12	15	Tracking CNS-related APANPIRG Conclusions/Decisions	Secretariat
WP/13	7.1	Review Report of Seventh Meeting of the Surveillance Implementation Coordination Group (SURICG/7)	Secretariat
WP/14	8.1	Review Report of the Third Meeting of ATM Automation Systems Task Force (ATMAS TF/3)	Secretariat
WP/15	9.1 & 9.2	Review of Regional CNS Requirements in ICAO APAC e-ANP, Seamless ANS Plan and Updates on National Air Navigation Plan (NANP)	Secretariat

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WP/20	15	CNS Points of Contact	Secretariat
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WP/22	7.2	Surveillance and DCPC VHF Coverage Maps Update	Thailand, Hong Kong China and Secretariat
WP/23	3.3	AMC Updates	Secretariat
WP/24	5.3	Amendment 91 to Annex 10 Volume III on Selective Calling Codes	Secretariat
WP/25	11	Standardizing the ATSEP Training for the Successful Implementation of the GANP	Nepal
WP/26	5.1	CAAC'S Support for the Enhancement of AEROMACS SARPS and Technical Manual	China
WP/27	13	Trial Flight and Standard Establishment of UAS-Based Flight Inspection in China	China
WP/28	6.3	Update of Flight Inspection Guidance Material (FIGM)	China & Hong Kong, China
WP/29	13	Provision of a Digital Tower and APRON Management System to Support Safe and Efficient Operation of the Hong Kong International Airport and Its Expansion	Hong Kong, China
WP/30	7.2	Inconsistent ICAO Aircraft Address and Target Identification Between Surveillance Data and Flight Plan	Hong Kong, China
WP/31	12.2	Ensuring Cyber Resilience for Air Navigation Service in Hong Kong International Airport and Its Expansion	Hong Kong, China
WP/32	2	Air Traffic Management and Airspace Safety Monitoring Outcomes	Secretariat
WP/33	9.1	Updates on Seamless ANS Plan	Secretariat
WP/34	4	Review Outcomes from MET SG/26	Secretariat & Chair of MET SG

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INFORMATION PAPERS			
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IP/02	3.1	Outcomes of Webinar on CRV Implementation	Secretariat
IP/03	5.2	Survey Result of the introduction of 50 kHz channel spacing for ILS and VOR facilities in the APAC region	Secretariat
IP/04	5.3	Outcomes of 5G/RA Webinar co-host with APT	Secretariat
IP/05	6.4	ITU Circular Letter on Prevention of Interference to GNSS	Secretariat
IP/06	9.2	Update on ICAO GANP Study Group related to CNS	Secretariat
IP/07	5.3	5G Network within Airport Boundary	Malaysia
IP/08	13	Development of Digital Tower Prototype at Changi Airport	Singapore
IP/09	5.1	Verification of Air Traffic Control Services Based on Data-Link for All Flight Phases in China	China
IP/10	5.3	Implementation and Application of VHF SELCAL in China	China
IP/11	6.4	BDS Standardization Status in ICAO	China
IP/12	6.4	LEO Navigation Augmentation Concept, Constellation Construction Status and Civil Aviation Application Research in China	China
IP/13	15	Flight Inspection Capability Building of CAAC for CNS Facility	China
IP/14	7.2	Research on ADS-B Position Verification	Japan/ENRI
IP/15	6.4	A Case of GNSS Signal Outage in the Oceanic Airspace in Japan	Japan
IP/16	6.4	Research and Development Activities related to GBAS in Japan	Japan
IP/17	6.4	SBAS Status Update in Japan	Japan
IP/18	9.1	The Long-Term Vision for the Future Air Traffic Systems of Japan (CARATS)	Japan/ENRI
IP/19	3.1	Challenges Faced in Joining CRV	AASL/Sri Lanka
IP/20	5.3	Outcome of APG23-4	Secretariat

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IP/21	4	Status of Proof of Concept Based SWIM Project for Exchanging Aeronautical Flight and Weather data	India
IP/22	3.1	Current Status of CRV Implementation in India	India/AAI
IP/23	15	IATA's aircraft Equipage and Capability Survey	IATA

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P/01	12.1	Updates on ICAO International Aviation Trust Framework	Secretariat
P/02	9.3	Global Developments Related to CNS	Secretariat
P/03	13	Comprehensive Applications of the Radar-based monitoring systems in Airport- Final	GLARUN Technology
P/04	13	Digital Towers, Resilience, Recovery, Refocus	SEARIDGE Technologies
P/05	4.2	Advanced Digitisation Facilitating Air Traffic Development	HUAWEI
P/06	13	Experience Sharing on Digital Towers	SAAB
