INTERNATIONAL CIVIL AVIATION ORGANIZATION

TWENTY SEVENTH MEETING OF THE ASIA/PACIFIC AIR NAVIGATION PLANNING AND IMPLEMENTATION REGIONAL GROUP (APANPIRG/27)

Bangkok, Thailand, 5 – 8 September 2016

Agenda Item 3: **Performance Framework for Regional air navigation planning and implementation**

3.4 **CNS**

REPORT ON THE TWENTIETH MEETING OF CNS SUB-GROUP

(Presented by Chairman of CNS SG)

SUMMARY

This paper presents the report of the Twentieth Meeting of the CNS Sub-group (CNS SG/20) held at the ICAO Regional Office, Bangkok, Thailand, from 11 – 15 July 2016. The meeting is invited to review the report and adopt the draft Decisions and Conclusions formulated by the Sub-group.

This paper relates to –

Strategic Objectives:

*A: **Safety** – Enhance global civil aviation safety*

*B: **Air Navigation Capacity and Efficiency**—Increase the capacity and improve the efficiency of the global aviation system*

*E **Environmental Protection** — minimize the adverse environment effects of civil aviation activities.*

1. INTRODUCTION

1.1 The Twentieth Meeting of the CNS Sub-group was held from 11 to 15 July 2016. The meeting was attended by 91 participants from 24 States/Administrations, IATA, IFALPA and two Industry Representatives and a COM Service Provider – Boeing, MITRE and SITA. A Summary Report of the meeting for consideration by APANPIRG/27 is provided in the Attachment to this paper. Full report of the Sub-group was posted on the ICAO APAC Office website and can be accessed at the following webpage: http://www2010.icao.int/APAC/Meetings/Pages/2016-CNS_SG20.aspx

2. DISCUSSION

2.1 The meeting considered 29 Working Papers and 23 Information Papers covering its 11 Agenda Items.

2.2 Based on the outcome of discussions on various Agenda Items, the meeting developed 12 Draft Conclusions and 5 Draft Decisions for consideration by APANPIRG/27 Meeting. In addition, the Sub-group made 2 Decision (20/3 and 20/12) relating to the establishment of SWIM Task Force and Dissolution of the Ionospheric Study Task Force. List of these outcomes are shown below:

Draft Decision CNS SG/20-D1	-	Creation of the Common Aeronautical VPN (CRV) Operations Group (CRV-OG)
Draft Decision CNS SG/20-D2	-	Revised TOR of Aeronautical Communication Services Implementation Coordination Group – (ACSICG)
Decision CNS SG/20-D3	-	Establishment of SWIM Task Force
Draft Conclusion CNS SG 20-C4	-	Asia and Pacific Flight Procedure Programme (APAC FPP)
Draft Conclusion CNS SG/20-C5	-	RNP 2 Implementation Guidance
Draft Decision CNS SG/20-D6	-	Revised TOR of Performance based Navigation Implementation Coordination Group
Draft Conclusion CNS SG20-C7	-	Protection of GNSS signal against jamming
Draft Conclusion CNS SG/20-C8	-	Revised Navigation Strategy for the Asia/Pacific Region
Draft Conclusion CNS SG/20-C9	-	GBAS safety assessment guidance related to anomalous ionospheric conditions
Draft Conclusion CNS SG/20-C10	-	SBAS safety assessment guidance related to anomalous ionospheric conditions
Draft Conclusion CNS SG/20-C11	-	Adoption of GBAS Ionospheric Threat Model and publication in Technical journal

Decision CNS SG/20-D12	-	Dissolution of Ionospheric Study Task Force (ISTF)
Draft Conclusion CNS SG/20-C13	-	Regulators' active support and engagement with ADS-B Implementation and Data sharing
Draft Conclusion CNS SG/20-C14	-	AIGD Amendment
Draft Decision CNS SG/20-D15	-	Dissolution of ADS-B Study and Implementation Task Force
Draft Decision CNS SG/20-D16	-	Revised TOR of Surveillance Implementation Coordination Group
Draft Conclusion CNS SG/20-C17	-	Revised Surveillance Strategy for the APAC Region
Draft Conclusion CNS SG/20-C18	-	Preparations for International Telecommunication Union (ITU) World Radiocommunication Conference 2019 (WRC-19)
Draft Conclusion CNS SG/20-C19	-	Workshop on competency-based training and assessment for the Air Traffic Safety Electronics Personnel (ATSEP)

2.3 A Summary Report of outcome of the CNS SG/20 Meeting including all Draft Conclusions and Draft Decisions is in Attachment to this paper for consideration by APANPIRG/27 Meeting. The Draft Decision CNS SG/20-D2, Draft Decision CNS SG/20-D6 and Draft Decision CNS SG/20-D16 are consolidated into a single Draft Decision in the Attachment.

2.4 For easy reference purpose, Appendices used in the CNS SG/20 Summary Report carry the same Appendices numbers as those in the full Meeting Report of the CNS SG/20.

2.5 The updated ATN/AMHS, AIDC and the ADS-B implementation status in the Asia and Pacific Regions are provided in the **Appendix A** and **Appendix L** to the CNS SG/20 Meeting Report.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

i) review the summary report on the outcome of CNS SG/20 meeting; and

ii) consider adoption of draft Conclusions and draft Decisions developed by the CNS Sub-group.

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Agenda Item 1: Adoption of agenda

1.1 The tentative agenda items presented in WP/01 was adopted by the meeting.

Agenda Item 2: Review outcome of relevant meetings:

DGCA Conf/52 Outcome (WP/02)

2.1 The meeting reviewed actions items developed by the 52nd Conference of Directors General of Civil Aviation (DGCAs), Asia and Pacific Regions (DGCA/52) held in Manila, Philippines from 26 to 30 October 2015. The Conference developed a total of 33 Action Items, 13 of which are relevant to work programme of the CNS SG namely Action Items 52/1, 52/2, 52/3, 52/4, 52/6, 52/7, 52/12, 52/14, 52/15, 52/17, 52/20, 52/21 and 52/32. The meeting urged States and Administrations to take action on the agreed Action Items and provide feedback on their actions. The meeting also noted the theme topic "Fostering Safe, Secure and Efficient Aviation System in an Eco-friendly Environment with No Country Left Behind" for DGCA/53 Conference which will be held in Colombo, Sri Lanka from 1 to 5 August 2016.

Action Item 52/15 on Guidance Material on acceptance of CNS Systems

2.2 The meeting discussed Action Item 52/15 and DP52/3.3/13 to DGCA/52 regarding the challenges faced by some States in the introduction of new CNS systems in respect of ICAO SARPs compliance. The Conference invited CNS Sub Group of APANPIRG to examine the feasibility for development of Guidance Material on a common methodology for introduction of new CNS systems and provide feedback to the 53rd DGCA Conference.

2.2.1 The meeting discussed this issue. Some States have regulatory requirements and procedures for validating and certifying CNS equipment before they could be put to use. Through IP/9, China shared its new generation CNS equipment, validation and certification processes. Such approval process not only applies to equipment made in China but also apply to equipment produced outside China but to be used in China. Viet Nam also indicated that they have similar procedures in place but validity for such approval is only for two years. Australia, Japan and Singapore expressed that according to SMS principles and requirements, it is the State's responsibility to review and accept safety assessments from their service providers to ensure that any critical new CNS system or procedure put to use is safe. The proposal in DP52/3.3/13 about type certificate of CNS system alone would not meet SMS requirements. The meeting encourages States/Administration to share their experience and lessons learnt in such validation and certification of CNS systems/procedures at the next meeting of the SG. In view of the foregoing, the meeting considered it would not be feasible to develop guidance material on a common methodology on this matter. As requested, the Secretariat provided the outcome of discussions as feedback to the DGCA/53 Conference.

FIT-ASIA/5 and RASMAG/21 Outcomes (WP/04)

2.3 The meeting noted the relevant outcome of the Fifth Meeting of the Future Air Navigation Systems Interoperability Team-Asia (FIT-Asia/5, 2-6 May 2016) and the Twenty-First Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/21, 14-17 June 2016.

ATM SG/4 Outcomes (WP/28)

2.4 The meeting was informed about the outcomes of Fourth meeting of the ATM Subgroup of APANPIRG (ATM SG/4) held in Bangkok from 6 to 10 July 2016.

2.5 The meeting supported following Draft Conclusions formulated by RASMAG/21 and endorsed by the ATM SG/4 meeting namely: *Draft Conclusion ATM/SG/4-1:PBCS Operator Requirements; Draft Conclusion ATM/SG/4-2: State Implementation of ICAO Provisions for PBCS and Draft Conclusion ATM/SG/4-3:Asia/Pacific Region PBCS Transition Strategy*. The meeting noted the draft Asia/Pacific Region PBCS Transition Strategy provided in Attachment A to the paper.

2.6 It was also informed that the ATM SG/4 meeting had endorsed a Draft Conclusion on the alternate regional arrangement for RNP 2 to be included in the flight plan subject to availability of global provision on this. It was also noted that ATM SG/4 had endorsed the South China Sea (SCS) Operational Concept developed by SEACG/23 as a useful means of identifying a common vision that was in line with the Asia/Pacific Seamless ATM Plan.

Origination and Distribution of Departure (DEP) Messages

2.7 The meeting noted that ATM SG/4 endorsed a Draft Conclusion regarding the importance of AFTN departure (DEP) messages in the management and coordination of flight plans in both manual and automated ATM environments. ICAO was requested to:

1. Conduct an analysis of the incidence of non-receipt of DEP messages required by ICAO Doc 4444 Procedures for Air Navigation Services (PANS-ATM) Section 11.4.2.2;

2. Request that States failing to ensure correct transmission of DEP messages promptly take corrective action and report the status of corrective actions to the ICAO APAC Regional Office by 30 April 2017; and

3. Raise APANPIRG Air Navigation Deficiencies against failure by States to comply with Doc 4444 Section 11.4.2.2, at APANPIRG/28.

2.8 In this connection, the meeting considered it necessary to forward the result of analysis of identified issues to ACSICG for further consideration, should the issues be identified as technical in nature.

Agenda Item 3: Aeronautical Fixed Service (AFS)

Report of ACSICG/3 meeting (WP/06)

3.1 The meeting reviewed and took action on the report of the Third Meeting of ACSICG held in May 2016: http://www.icao.int/APAC/Meetings/Pages/2016-ACSICG3.aspx

3.2 It was encouraging to note that some more AMHS implementation plans and relevant activities had progressed during 2015 and beginning of 2016 in the Region. Additional TMC between States/Administrations were being discussed and/or signed to progress the implementation of AMHS between States/ Administrations. The meeting expressed appreciation to those States/Administrations that made efforts in implementation of AMHS since the ACSICG/2 meeting. The meeting noted the updated AMHS implementation planner and the Regional ATN/AMHS/AIDC implementation status table updated by APA TF/2 meeting in March 2016 and ACSICG/3 meeting. The implementation status consolidated in the table is provided in **Appendix A** to this Report.

Updates on the anticipated use of VSAT in some Pacific States

3.3 New Zealand informed ACSICG/3 meeting that the Phase 2 of the World Bank PAIP VSAT Deployment project is planned to provide additional connectivity but no implementation dates had been set yet (This project provides VSAT connectivity among a number of Pacific Islands States so as to support IP-based AFTN/AMHS connections and voice. Phase 1 of the project, supposed to be implemented in Q3 2012, and would deploy VSAT remote stations in some of these Pacific States. The New Zealand Ministry of Foreign Affairs and Trade (MFAT) is funding VSAT stations for Rarotonga, Aitutaki (Cook Islands), and Niue.

3.4 It was noted that AFS connections are also required between Nadi and some locations mentioned in the project for message/data communication as specified in the AFTN plan and ATN routing plan of regional air navigation plan (e-ANP). Considering that alternate routing for data/message communications are also required from redundancy perspective, States concerned are encouraged to keep the existing circuits implemented while making efforts in improving the both voice and data communication through the World Bank project.

AIDC Traffic over AMHS

3.5 While more and more AMHS connections are put into operations, the AIDC traffic being exchanged over AFTN are transferred or planned to be exchanged over AMHS. Since the AIDC ICD including the pan inter-regional ICD for AIDC is still based on AFTN format, the AIDC messages would be capsulated into the AMHS messages. States and Administrations were urged to share such successful implementation at the ACSICG/4 meeting.

AMC Information Update and SITA-AMHS Address

3.6 Thailand informed the meeting that some updated information from a number of States had been integrated into the EUROCONTROL AMC Database since ACSICG/2 meeting following the AIRAC cycle.

3.7 SITA registered with PRMD name SITA as a part of ADMD=ICAO. This PRMD name is registered within AMC. On 11 January 2016, AMC informed all COM Centres worldwide of the introduction of the SITA PRMD and asking related routings and addressing to be coordinated by the AMC. On 26 May 2016 at 1100UTC, there will be two AMHS SITA Gateways operational in the EUR Region at EDDD and LSSS COM Centres. All interconnected AMHS COM Centres shall implement the AMHS User Address table and shall route the PRMD=SITA to the AMHS SITA Gateways EDDD or LSSS on 26 May 2016.

3.8 There are three AMHS/SITA gateways in APAC region i.e. Bangkok, Brisbane and Singapore. Thailand informed the meeting that SITA/AMHS connection gateway had been installed. The test between Thailand's AMHS system and the SITA/AMHS gateway was performed; however, the connection is not operational. Australia and Singapore confirmed that negotiation with SITA had taken place for installation of SITA/AMHS connection gateways in Brisbane and Singapore respectively.

3.9 The meeting considered that this change would impact network operation of AMHS. It was identified that there would be needs for further coordination between local users of operators and SITA as well as investigation by States/Administrations about the traffic to/from SITA gateway in Europe.

3.10 As SITA is implementing AMHS and migrating the type B traffic into AMHS service, there are many potential unknown originators that have not been included in the addresses table in AMC. Then, it would cause AMHS to reject the messages and could overwhelm the service.

3.11 As contingency and temporary solution for the potential AMHS network operational problems, the meeting developed near and long term solutions for consideration by the States.

AMHS profile for the IWXXM data exchange

3.12 Through a Paper for ACSICG meeting, USA introduced a working paper for the sixty-second Aeronautical Fixed Service Group (AFSG) detailing an AMHS profile for IWXXM data exchange. Amendment 76 to ICAO Annex 3 – Meteorological Service for International Air Navigation (Nov. 2013) enables, under bilateral agreements between States *in a position to do so*, the exchange of METAR, SPECI, SIGMET and TAF in a digital form (XML/GML) in addition to Traditional Alphanumeric Codes (TAC) forms. With applicability of Amendment 77 (Nov. 2016), METAR, SPECI, SIGMET and TAF, plus volcanic ash advisory information, tropical cyclone advisory information and AIRMET, **should be** exchanged in a digital form. Finally, with applicability of Amendment 78 (expected by Nov 2018 or Nov. 2019) it is envisaged that the above meteorological information **shall be** exchanged in a digital form.

3.13 The ICAO Meteorological Information Exchange Model (IWXXM) is a data model built on the ISO TC211 standards for exchanging operational meteorological (OPMET) data. Guidance on the information exchange model, XML/GML and the metadata profile is provided in the ICAO Doc 10003 − *Manual on the Digital Exchange of Aeronautical Meteorological Information.*

3.14 As Air Traffic Services (ATS) Message Handling System (AMHS) is being implemented internationally, it has been identified as an appropriate protocol for distributing aeronautical meteorological information in digital form. The Working Paper presented at the sixty-second Aeronautical Fixed Service Group (AFSG) introduced an AMHS profile to carry IWXXM data.

3.15 Australia reminded the ACSICG/3 meeting of the Attachment E to the State Letter AN 10/1.1-16/17 regarding Amendment 77 to Annex 3 which provides implementation task list and outline of guidance on implementation including modification to the national regulations and means of compliance.

Outcome of the Fifth Meeting of Common Regional VPN Task Force

3.16 The meeting noted a recommendation for creation of the Common aeRonautical VPN Operation Group (CRV OG). The initial CRV-OG rules and procedures were agreed by the CRV TF. The meeting reviewed the draft TOR of CRV OG provided in **Appendix B** to the Report. The meeting also noted the high level outline of the ICAO APAC CRV OG Operations Manual (Appendix F to the CRV TF/5 Report). Accordingly the meeting endorsed the following Draft Decision formulated by CRV TF/5:

<table>
<tr><td colspan="2">Draft Decision CNS SG/20 - D1: Creation of the Common Aeronautical VPN (CRV) Operations Group (CRV-OG)</td></tr>
<tr><td>That, the Common Aeronautical VPN Operations Group (CRV-OG) be established with Terms of Reference provided in Appendix B to the Report.</td><td>Expected impact:
☐ Political / Global
☒ Inter-regional
☒ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="2">Why: CRV-OG is required for the second phase of the CRV project once the common service provider is selected.</td></tr>
<tr><td>When: September 2016 once approved by APANPIRG & first meeting is scheduled for December 2016.</td><td>Status: Draft to be adopted by APANPIRG</td></tr>
<tr><td colspan="2">Who:☒Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☒APANPIRG ☐ Other:</td></tr>
</table>

Second Meeting of AP AIDC Task Force (WP/05)

3.17 The Secretariat presented the report of the Second meeting of the ATS Inter-facility Data Communication Task Force (APA TF/2) which was held in Bangkok, Thailand from 16 to 18 March 2016, the report of which is placed at: http://www.icao.int/APAC/Meetings/Pages/2016-APA-TF2.aspx

3.18 The meeting noted the following main outcomes of the APA TF/2 meeting:

a) Updated status of AIDC implementation in APAC region reflected in the Appendix A to the report of this meeting;
b) Development of Version 0.1 of the Asia/Pacific AIDC Implementation Guidance material;
c) AIDC Issues being identified by the APA TF and consolidated in the issue form; and
d) Agreed on the target date and implementation plan focusing those connections identified with priorities

3.19 The meeting recalled the safety issues identified by APANPIRG relating to human errors during ATS transfer. Considering that ATS Inter-facility Data Communications (AIDC) is an important means of minimizing Large Height Deviations (LHD), States/Administrations concerned agreed to the implementation plan for the following significant LHD interface areas:

a) **Indonesia:** between Jakarta and Chennai/Ujung Pandang/Melbourne FIRs

– Dec. 2018 which is the target date for ATM system at Jakarta be replaced.
Note: AIDC trials between Brisbane and Makassar ATSCs had been carried out for number of years. Currently has issue of message delay. It is expected to be implemented in December 2016.

b) **India:** between Chennai and Kuala Lumpur FIRs;

AIDC trial operations without voice confirmation were commenced from 25th February 2016. Currently both sides are working on the LOA approval. The target date of implementation by December 2016.

c) **Philippines:** between Manila FIR and Fukuoka / Taibei /Hong Kong/Ho Chi Minh/Singapore/ Kota Kinabalu /Ujung Pandang FIRs;

- with Fukuoka: 4Q2017; (at CNS SG/20, Japan expressed that a target date of implementation will be confirmed by Japan);
- with Taibei: 4Q2016;
- Hong Kong: to be confirmed later with CAD Hong Kong;
- Ho Chi Minh: testing by end of 2016 and implementation by 4Q2017;
- Singapore: 3Q2016;
- Kota Kinabalu : to be confirmed; and
- Ujung Pandang: 1Q2017

3.20 In addition to the above significant LHD interface area identified by APANPIRG, the need for AIDC connection with Oakland was also identified. (USA proposed the target date for establishment of AIDC with the Philippines in 4Q2017.)

c) **China:** between –

i. Urumqi and Lahore FIRs **(**VSAT voice communication being established**)**; and

(4Q2016 is the target date of implementation of this VSAT link)

ii. Beijing and Ulaan Baatar FIRs. (Secretariat was requested to facilitate discussions for implementation planning between China and Mongolia)

3.21 Regarding implementation of PAN regional ICD for AIDC, Hong Kong China recommended that clear guidelines should be provided to States/Administrations to take care of the compatibility issues on interfacing with older AIDC versions.

Outcomes of ICAO SWIM workshop (WP/08)

3.22 The ICAO SWIM workshop 2016 was held in Bangkok, Thailand from 16 to 18 May 2016, gathering a total of 126 participants from APAC and MID States/Administrations and industry. The workshop agreed on 26 keynotes that were reviewed by the meeting. The meeting also reviewed the work programme on SWIM.

3.23 The scope of a regional work programme was developed by an informal group by the end of June 2016 based on the draft ACSICG work programme. The informal group further identified the different tasks of the work programme, and some dependencies (deliverables of IMP, other). This formed the basis taken by the meeting to develop the terms of reference of the SWIM Task Force.

Mini Global Demonstration project (WP/18)

3.24 Thailand presented the participation of Japan, Singapore, and Thailand in the Mini Global Demonstration project led by USA, to foster the seamless information sharing and global interoperability based on SWIM (System-Wide Information Management) concept, in support of ICAO GANP (Global Air Navigation Plan). The meeting was informed about the activities carried out in the project, including the global and Asia/Pacific regional demonstrations held in April and May 2016 and lessons learnt from the development of technical support systems.

SWIM Implementation Plan (WP/20)

3.25 USA recommended that a group be established to implement SWIM in APAC region, coordinate requirements with applications/system owners, develop a regional structure to manage the new service, and develop dual operations to support both legacy service and new service to prevent duplicated messages as well as rejected messages.

SWIM Regional Group (WP/19)

3.26 Building on their experience and recent demonstrations of benefits achieved through SWIM, Japan, Singapore and Thailand recommended the meeting to endorse the establishment of a SWIM Task Force for the APAC region focusing on project management of B1-SWIM and related topics. The proposed Terms of Reference for SWIM Task Force was developed by an Ad Hoc working group consisted of members from Australia, China, Japan, Singapore, Thailand and USA. Accordingly, the meeting adopted the following Decision:

Decision CNS SG/20 - D3: Establishment of SWIM Task Force	
That, the SWIM Task Force be established with the terms of reference placed at **Appendix D**.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical

<table>
<tr><td colspan="2">Why: A task force is needed to achieve the objectives of B1-SWIM and of the seamless ATM plan related to SWIM.</td></tr>
<tr><td>When: 15-Jul-16</td><td>Status: Adopted by Subgroup</td></tr>
<tr><td colspan="2">Who: ☐Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☒Other: IATA, ICCAIA</td></tr>
</table>

3.27 The draft work programme of the Task Force was further reviewed by the meeting and is placed at **Appendix E**.

Agenda Item 4: Aeronautical Mobile Service (AMS)

Review regional Strategy on Aeronautical Mobile Service

4.1 The Secretariat presented the regional AMS Strategy for review by the meeting. It was recalled that the current strategy was adopted by APANPIRG/24 through Conclusion 24/35 in 2013. The strategy was updated by CNS SG/17 meeting in May 2013.

4.2 The CNS SG reviewed the regional AMS Strategy and did not identify the need to amend the regional AMS Strategy during the meeting.

Boeing ATS Datalink Experience and Capabilities (IP/19)

4.3 Boeing made a presentation highlighting Air Traffic Services (ATS) data link including usages, options, technology, architecture, infrastructure, applications and benefits. The presentation also provided a brief overview of the current status of the FAA Data Communications Program. The presentation recalled the history and current implementation status of Aircraft Communications Addressing and Reporting System (ACARS) - based ATS data link communications including FANS and ATN applications. ATS data link continues to evolve, with newly-defined applications on the horizon. The primary purpose of the ATS datalink is to integrate avionics and ground automation to enable beneficial capabilities not possible with voice communications and the secondary purpose is to supersede voice communications when and where appropriate. Integrated Datalink (such as FANS-1/A) is a key to the introduction of near-term trajectory-based operations (TBO).

Boeing and Industry Activities regarding ATN using IPS (IP/20)

4.4 Boeing provided information on the current activities performed by Boeing, along with other joint research partners, regarding progressing Aeronautical Telecommunications Network – Internet Protocol Suite (ATN/IPS). This presentation also introduced related activities of standards groups involving ATN/IPS.

4.5 ICAO Doc 9896 defines a number of key technical areas that are necessary for implementation of ATN/IPS. There are many technical details that need further validation and consideration. It was stated that additional standardization may be required in order to realize an implementation of ATN/IPS in industry. This would include standards that would need to be developed in the Airlines Electronic Engineering Committee (AEEC), Radio Technical Commission for Aeronautics (RTCA), and other groups. Boeing and other industry partners have helped to create a synergistic standards development effort involving these organizations to progress the IPS standards. The benefits and roadmap (Boeing vision) were also introduced.

Agenda Item 5: Navigation

5.1 **Outcomes of the PBNICG/3 meeting (WP/09)**

5.1.1 The outcomes of the third Meeting of the Performance Based Navigation Implementation Coordination Group (PBNICG/3) held from 08 to 10 March 2016 were reviewed by the meeting.

5.1.2 Considering the importance of continuing participation of States for the success of APAC FPP and the need for assistance of APAC States, the Secretariat recommended that any State not participating in the APAC FPP join the programme and support its expansion into Phase 3 (2018-2020). In this regard, the meeting endorsed to the following Draft Conclusion:

<table>
<tr><td colspan="4">Draft Conclusion CNS SG/20 - C4: Asia and Pacific Flight Procedure Programme (APAC FPP)</td></tr>
<tr><td colspan="3">That, considering the benefits derived from APAC FPP support, State not participating in the Asia and Pacific Flight Procedure programme (APAC FPP) consider joining the programme and if so, coordinate with the ICAO APAC Regional Office.</td><td>Expected impact:
☒ Political / Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="4">Why: APAC FPP enhances capacity of States in PBN implementation</td></tr>
<tr><td>When:</td><td>8-Sep-16</td><td colspan="2">Status: Draft to be adopted by PIRG</td></tr>
<tr><td>Who:
Other: APAC FPP</td><td colspan="3">☐Sub groups ☒APAC States ☒ICAO APAC RO ☐ICAO HQ ☐</td></tr>
</table>

5.1.3 Regarding the submission of PBN implementation plans, the meeting noted that so far the following 27 States/Administrations had submitted their PBN Implementation Plan: Australia, Bangladesh; Cambodia; China; Hong Kong, China; DPR. Korea; Fiji; India; Indonesia; Japan; Lao PDR.; Malaysia; Maldives; Mongolia; Myanmar; Nepal; New Zealand; Pakistan; Papua New Guinea; Philippines; Republic of Korea; Singapore; Sri Lanka; Thailand; Tonga; Viet Nam and French Polynesia.

5.1.4 The meeting noted also the forecast that the bulk of APAC States would not meet the Assembly Resolution 37-11 objectives end 2016 for international and domestic runway ends. The meeting endorsed the recommendation from PBNICG that such States should review their PBN implementation plan to speed up implementation and continue sharing with PBNICG all the issues they may face. Even though they cannot meet Assembly Resolution 37-11 objectives of 100% end 2016, the updated PBN plans should give an ambitious but reachable target for end 2016, and plan a date at which the Assembly Resolution 37-11 objectives will be met.

5.1.5 In terms of PBN arrival and departure route development, the meeting endorsed PBNICG recommendation that States connect their PBN arrival procedures to the approach procedures.

5.1.6 The main issues hampering PBN implementation progress were noted as follows:

- Some airports had published PBN procedures which are still not being used effectively;

- Approved and published procedures are not flown by operators;
- Approved and published procedures are normally not cleared by ATC;
- Need updated information about airport´s Obstacle Limitation Surface (OLS);
- Procedures had been developed but not yet been approved/published;

- perational approvals of aircraft operators are below fleet's operational capabilities;

5.1.7 The meeting reviewed and endorsed the updated terms of reference for PBNICG, introducing mostly the possibility for PBNICG to raise and solve deficiencies in the area of PBN. While PBNICG/3 endorsed a Draft Conclusion in this respect, the updated terms of reference for PBNICG were endorsed through a common Draft Conclusion under agenda item 8.2.

5.1.8 Noting the equivalence for RNP 2 recognized by Australia (RNAV 2, RNP 1 GNSS) and the issue with the flight plan not directly recognizing RNP 2 (note: RNP 2 could be indirectly indicated by use of the designator 'Z' in item 10 and 'NAV/RNP 2' in item 18), the meeting further amended and endorsed the following Draft Conclusion formulated by PBNICG/3 which was also endorsed by ATM SG/4 meeting:

<table>
<tr><td colspan="2">Draft Conclusion CNS SG/20 - C5: RNP 2 Implementation Guidance</td></tr>
<tr><td>That, for the implementation of RNP 2:

a/ States should ensure that all aircraft operators file* the designator 'Z' in item 10 and 'NAV/RNP2' in item 18 to indicate RNP 2 capability until the ICAO flight plan format is amended by ICAO to include RNP 2 (such as by using the flight plan PBN Designator 'P2');

b/ ICAO be invited to harmonize the procedure above globally; and

c/ an equivalence for RNP 2 is recognized if the aircraft is approved for RNAV 2, RNP 1 and GNSS but not approved for RNP2.</td><td>Expected impact:
☐ Political / Global
☒ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="2">Why: Failing these conditions, the implementation of RNP2 (seamless ATM objective for en route airspace) will be hampered and its benefits in terms of route spacing not reaped.</td></tr>
<tr><td>When: 8-Sep-16</td><td>Status: Draft to be adopted by PIRG</td></tr>
<tr><td colspan="2">Who: ☐Sub groups ☒APAC States ☒ICAO APAC RO ☒ICAO HQ ☐Other:</td></tr>
</table>

*Notes:

- The designator Z in item 10 and NAV/RNP2 in item 18 should be filed with no brackets
- R is not required in item 10a with NAV/RNP2; R is filed in item 10a if PBN/ is filed in item 18 to indicate other PBN capability

PBN Course for decision makers

5.1.9 The PBNICG/3 meeting discussed the follow-up work by IATA and ICAO regarding the action 2/13 from the PBN workshop in 2015 to provide necessary training to the decision makers and executives in CAAs who make decisions about the funding of PBN implementation projects. The meeting considered that the one day training in conjunction with APANPIRG would miss its target, as most APANPIRG participants have already a knowledge regarding PBN strategy and implementation. The initial intention of the ICAO PBN Seminar was to provide training to the Directors Generals of Civil Aviation. As a result, the meeting agreed that one hour briefing for DGs and Directors involved in PBN Strategy would bring added value. The briefing should be built upon the ICAO PBN iKit, IATA expertise and also the recently developed Australian PBN CNS-ATM package in the form of an interactive presentation, addressing the following topics:

- PBN concept and its benefits
- scope of PBN projects that are possible (simple to complex)
- business case elements and process (Safety and Efficiency)
- consultative process and importance of involving all aviation stakeholders to have bought in
- implementation process (generic – as each country may have different processes) including the approval process
- Conduct a case study example

5.2 **PBN Deployment and Issues Encountered (WP/25)**

5.2.1 Australia updated the meeting about their progress in implementing PBN in Australia, in particular the high percentage of flights currently conducting PBN operations.

5.2.2 Australia reported that at the end of a 4 year notice periods, on AIRAC Cycle 26 May 2016, 180 Terrestrial Navigation Aids (NDBs and VORs) and associated Non Precision Approach Procedures, were withdrawn from service. 220 Terrestrial Navigation Aids have been retained to provide contingency navigation including Non Precision Approach for any aircraft encountering difficulty navigating with PBN, typically caused by some difficulty in using GNSS. Routes associated with a withdrawn navigation aids were either transferred to another navigation aid (i.e. DN NDB withdrawn, routes transferred to DN VOR) or replaced with a waypoint, 5 letter designator.

5.2.3 Australia further reported about its RNP2 exemption process for foreign operators. Since some States cannot issue RNP 2 Approvals, a number of foreign operators conducting flights to Australia have aircraft with RNP 2 capability but are unable to have RNP 2 listed on their Operations Specification. As a result CASA published an exemption that allows foreign aircraft with RNAV 2 and RNAV 1 capability based on GNSS in their Operations Specification to operate RNP 2 in Australian FIRs.

GNSS interference (WP/23)

5.2.4 China shared its experience about GNSS interference. In one instance, in November 2015, the flight inspection system of a flight inspection aircraft failed while carrying out flight inspection to a runway end at Chengdu Airport. The illegal source of interference was identified by the China civil aviation regulator and shut down. Another instance of interference made by drivers who installed Beidou interference equipment on board their vehicles (such as those carrying dangerous goods) as they did not want to be tracked by the Highway Agency which have mandated carriage of Beidou receivers on board their vehicles. Such Bediou interference equipment affected nearby general aviation airports. China reported that it had the capability to determine source(s) of GNSS interference and is refining its response mechanism. The meeting noted that single-frequency GNSS is susceptible to radio frequency interference and ionospheric disturbances while multi-frequency multi-constellation GNSS may mitigate risks caused by narrow band frequency interference and ionospheric disturbances. The meeting also agreed that GNSS interference would best be dealt with by education, appropriate regulation and active detection and elimination of intentional and unintentional interference sources.

5.2.5 In the past APANPIRG already adopted Conclusion 22/28 - *Protection of aviation utility of GNSS, that, State aviation authorities in partnership with other agencies of the State prohibit malicious and unintentional interference to GNSS and regulate legitimate uses of technology to preserve aviation utility of GNSS.*

5.2.6 However, with more and more States facing the reality of GNSS jamming, the meeting endorsed the following Draft Conclusion. In nature, it complements *Conclusion 22/28* and points out specifically the mitigations:

Draft Conclusion CNS SG/20/ - C7: Protection of GNSS signal against jamming	
That, considering the reported occurrences of jamming of GNSS signal in APAC region and their effects on safety of civil aviation operations, States be urged to: 1. protect all the Aeronautical Radio Navigation Service (ARNS) frequencies; 2. take proactive measures to educate public about potential consequences of GNSS spoofing and jamming on civil aviation operations; 3. detect and eliminate jamming through an efficient response mechanism, in particular in the vicinity of aerodromes; and 4. continue to report occurrences of GNSS interference and their effects to ICAO APAC Regional Office.	Expected impact: ☒ Political / Global ☒ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: Occurrences of jamming of GNSS signal in APAC region (China, Republic of Korea, Australia, etc.) that have caused delays on operations were reported.	
When: 8-Sep-16	Status: Draft to be adopted by PIRG
Who: ☐Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐ Other:	

5.2.7 The meeting reviewed the regional Navigation Strategy based on a recommendation from China. The meeting established an Ad Hoc working group consisting of Australia, Bangladesh, China, Japan and USA (group leader) to review the Strategy. The meeting endorsed the revised Regional Navigation Strategy as shown in **Appendix F** and formulated the following Draft Conclusion:

Draft Conclusion CNS SG/20 – C8: Revised Navigation Strategy for the Asia/Pacific Region	
That, the revised Navigation Strategy for the Asia/Pacific Region provided in **Appendix F to** the Report be adopted .	Expected impact: ☒ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: Occurrences of jamming of GNSS signal in APAC region, relevant considerations and strategy being included in the regional navigation strategy	
When: 8-Sep-16	Status: Draft to be adopted by PIRG
Who: ☐Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐Other:	

5.3 Review the outcome of Sixth Meeting of Ionospheric Studies Task Force (ISTF/6)

5.3.1 The Ionospheric Studies Task Force (ISTF) has been working on the coordinated ionospheric data collection, analysis and sharing in the Asia-Pacific (APAC) region since 2011. The major goals of the ISTF activities were to study the need for development of regional ionospheric threat models for GBAS and SBAS, to develop them if the need is identified, and to investigate the effects of space weather on CNS systems in the APAC Region. Since the large part of the APAC region is in the low magnetic latitude region, ionospheric disturbances characteristic of the low magnetic latitude region and their effects on GNSS are of the region's great interest.

5.3.2 To achieve the goals, six tasks were identified as follows:

1. DATA COLLECTION: Identification of data source, GNSS data collection, sharing, distribution and archiving. Identification of data sharing format;

2. IONO ANALYSIS: Identification of analysis methodology and GNSS ionospheric data analysis;

3. TEC GENERATION: GNSS total electron content (TEC) gradient data generation;

4. SCINTILLATION DATA: GNSS ionospheric scintillation data generation;

5. IONO MODEL: Assessment of need to Regional GBAS and SBAS ionospheric models and development of these models if it is needed; and

6. SPACE WEATHER: Analyze, based on data shared within ISTF and public information, the effects of space weather and the concept of operations for the provision of space weather information in support of international air navigation

5.3.3 Regarding Task 1, GNSS data from Australia, Hong Kong, India, Indonesia, Japan, Philippines, Singapore, Thailand, APEC GIT testbed, and United States were collected and analysed by ISTF. To make the data exchange easier, ISTF proposed two data exchange standards, GTEX and SCINTEX for ionospheric delay and scintillation data, respectively that were adopted under Conclusion APANPIRG/26/38 – Standard for exchange and sharing of GNSS data in the APAC Region by APANPIRG in 2015. Task 1 is completed.

5.3.4 Regarding Task 2, ISTF identified common analysis tools. To identify the days of storm, AATR analysis tool developed by ENRI was used. For ionospheric delay gradient estimation, the LTIAM (Long-term Ionosphere Anomaly Monitoring) tool was used with FAA's permission. ENRI also developed an alternative ionospheric delay gradient analysis tool based on the SF-CBCA (Single-frequency carrier-based and code-aided) technique and made it available for ISTF. The SF-CBCA technique has been manually validated to provide comparable results with those based on simultaneous dual-frequency measurement data, which is in principle equivalent to the methodology used in the LTIAM. Thus, Task 2 is completed.

5.3.5 For Tasks 3 to 5, the data analysis for GBAS was performed by sharing analysis efforts. According to the results of analysis, it was noted that the maximum gradients obtained in the Asia-Pacific region exceed the upper limit of the CONUS model (425 mm/km) and that of the model used in the technical validation of the GAST-D baseline SARPs (500 mm/km). Therefore, the need of regional threat model was confirmed through *APANPIRG Conclusion 26/37: – Need for ionospheric models in the APAC Region.*

5.3.6 The GBAS safety assessment guidance related to anomalous ionospheric conditions was prepared by ISTF to assist States in their safety assessment of ionospheric threat and mitigation to GBAS signal. The major contents are:

- Ionosphere conditions to consider for GBAS safety analysis
- Development and validation of the threat model
- Post-implementation activities
- Examples of GBAS ionospheric threat model

5.3.7 The meeting endorsed the following Draft Conclusion:

Draft Conclusion CNS SG/20 - C9: GBAS safety assessment guidance related to anomalous ionospheric conditions			
That, the GBAS safety assessment guidance related to anomalous ionospheric conditions be adopted and published on the ICAO APAC website.			Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To assist APAC States lying in the low magnetic latitude region in their safety assessment of ionospheric threat to GBAS signal and mitigation.			
When:	15-Nov-16	Status:	Draft to be adopted by PIRG
Who: ☐Sub groups ☒APAC States ☒ICAO APAC RO ☐ICAO HQ ☐Other:			

5.3.8 The GBAS safety assessment guidance related to anomalous ionospheric conditions is provided in **Appendix G** to the Report.

5.3.9 The SBAS safety assessment guidance related to anomalous ionospheric conditions was likewise prepared by ISTF to assist States in their safety assessment of ISTF threat and mitigation to SBAS signal. The major contents are:

- Overview of GNSS and SBAS
- Threat Mitigation Strategy Against Anomalous Ionospheric Conditions
- Approval of SBAS
- Ionosphere Algorithms for WAAS/MSAS

Draft Conclusion CNS SG/20 - C10: SBAS safety assessment guidance related to anomalous ionospheric conditions			
That, the SBAS safety assessment guidance related to anomalous ionospheric conditions be adopted and published on the ICAO APAC website.			Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: To assist APAC States lying in the low magnetic latitude region in their safety assessment of ionospheric threat to SBAS signal and mitigation.			
When:	15-Nov-16	Status:	Draft to be adopted by PIRG
Who: ☐Sub groups ☒APAC States ☒ICAO APAC RO ☐ICAO HQ ☐ Other:			

5.3.10 The SBAS safety assessment guidance material related to anomalous ionospheric conditions is attached to the report as **Appendix H**.

5.3.11 Regarding the scintillation data, the task force evaluated that scintillation is not likely to be a threat to integrity despite potential degradation in availability, and decided not to generate any scintillation occurrence model. Instead, the potential impacts of scintillation on SBAS and GBAS are described in the SBAS/GBAS safety assessment guidance. A guidance document on scintillation measurements was prepared by ISTF and is attached to the report as **Appendix I. (**ISTF/3-WP/9, Guidance material on scintillation measurements, ISTF/3, Seoul, Republic of Korea, October 2013).

5.3.12 The remaining work to be completed was to publish the GBAS ionosphere threat model in a technical journal. It would require some more data analysis to complete the model and have it technically validated by a peer-review process. This work would be completed through ISTF web conferences by December 2016. Therefore the meeting endorsed the following Draft Conclusion:

Draft Conclusion CNS SG/20 - C11: Adoption of GBAS Ionospheric Threat Model and publication in Technical journal			
That, the APAC GBAS Ionospheric Threat Model be adopted, remain the intellectual property of ICAO and be published in the public domain in selected Technical journals with the list of author/contributors as per **Appendix J**.		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: To mitigate ionospheric threat to GBAS signal for States in the APAC low magnetic latitude region.			
When:	13-Jan-17	Status:	Draft to be adopted by PIRG
Who: ☐Sub groups ☒APAC States ☒ICAO APAC RO ☐ICAO HQ ☐Other:			

5.3.13 Regarding Task 6 of Space weather, the major topic of this task was to review the concept of operations for space weather information in support of international air navigation (Space Weather ConOps) from the APAC's regional point of view and make necessary inputs. The Space Weather ConOps is being prepared by the Working Group on Meteorological Information and Service Development (WG-MISD) under the ICAO MET panel. ISTF reviewed possible impacts of space weather phenomena on CNS systems and summarized potential operational improvements by mitigating them by utilizing space weather information. The document also identified operational requirements for space weather information. The document will be presented as a study note at the second face-to-face meeting of WG-MISD from 11 to 13 July 2016 in Montreal, Canada by two common members of ISTF and WG-MISD under the ICAO MET Panel. The study note is attached to the report as **Appendix K**.

5.3.14 Considering the achievements described above, and that all goals of ISTF will have been successfully achieved around December 2016, the meeting endorsed the following Draft Decision:

Decision CNS SG/20 - D12: Dissolution of Ionospheric Study Task Force (ISTF)			
That, considering that all tasks mentioned in the terms of reference of ISTF are completed, and that in the case where the peer-review process of the technical publications is not successfully completed, CNS SG would handle the follow-up work, the Ionospheric Studies Task Force be dissolved.		Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical	
Why: All goals of ISTF will have been successfully achieved around December 2016.			
When:	31-Jan-17	Status:	Adopted by Subgroup
Who: ☐Sub groups ☒APAC States ☒ICAO APAC RO ☐ICAO HQ ☐Other:			

5.3.15 Hong Kong China proposed that later on, as more APAC States/Administrations start to consider GBAS, a regional work group or task force may assist them in their implementation.

MSAS Status and Future Plan (IP/07)

5.4 Japan updated the meeting about status of its SBAS configuration and future plan. One of the two MTSAT satellites had been decommissioned in 2015, after about 10-year service. To maintain availability and continuity of service after this decommissioning, dual PRN (Pseudorandom noise code) operation had been initiated, that is two SBAS PRN signals were sent to the remaining MTSAT satellite which would be decommissioned in year 2020. Quasi-Zenith Satellite System (QZSS), with one geostationary orbit satellite and three geosynchronous inclined orbit satellites, would start operation in 2018 to take over SBAS capability from MTSAT satellite in 2020.

Status of Korean SBAS Programme (IP/12)

5.5 Republic of Korea updated the meeting about its SBAS implementation calls KASS (Korea Augmentation Satellite System) which will be owned and operated by Korea's Ministry of Land, Infrastructure and Transport. KASS' signal-in-space will be broadcasted by leased navigation payloads on two GEO satellites. Development work of KASS started in end 2014, with an open service planned for 2020 and safety-of-life service commissioned by 2022. KASS will be jointly developed by a Korean contractor and an international contractor who has experience in SBAS. The KASS Program consists of two projects, one deal with provision of Approach with Vertical Guidance capability in the Korean Peninsula area (project started in end 2014) and other deals with R & D for CAT 1 technology such as use of Multi-frequency Multi-constellation satellites.

GBAS Implementation Plan in Japan (IP/8)

5.6 Japan presented its plan about implementing CAT 1 GBAS at Tokyo Haneda Airport based on decision of CARATS. The decision was made in 2015 after positive R & D activities on GBAS as achieved by Japan Electronic Navigation Research Institute (ENRI), worldwide implementation of GBAS as well as favourable cost-benefit analysis. GBAS implementation at Haneda Airport has already begun this year, with installation to be completed by March 2019. Operational evaluation will follow after completion of installation, with start of CAT 1 operation expected in fiscal year 2020. Decision about CAT III GBAS operation will be made after successful implementation of CAT I GBAS at Haneda and also assessment of airborne equipage.

Enhancing ATM Flight Plan Processing for the PBN Environment (IP/16)

5.7 New Zealand presented a paper highlighting the problems it encountered while enhancing automated processing of flight plans in New Zealand (NZ) ATM system starting in late 2014. This is to support NZ's move to a PBN environment. However, it was found that the new flight planning provisions introduced in 2012 had limitations and also were not fully understood by some aircraft operators, resulting in supply of inaccurate information. Moreover, clarifications were also done with affected operator's fleet to fully understand their PBN capabilities, as ATC had encountered situations when flights with appropriate PBN capability had not included this in flight plans and also when a capability had been notified, but the flight was in fact not capable. Apparently, aircraft operators did not fully appreciate the effect on their operations of incorrectly or inadequately filed PBN information. New Zealand found that co-operation and close liaison with aircraft operators produced more effective and rapid resolutions to mutual problems than threatened punishment or legislation, and promotes a healthy ongoing relationship between the ANSP and aircraft operators.

Agenda Item 6: Surveillance

Outcome of ADS-B SITF/15 (WP/11)

6.1 Under this agenda, the meeting reviewed the report of the Fifteenth Meeting of the Automatic Dependent Surveillance – Broadcast (ADS-B) Study and Implementation Task Force

(ADS-B SITF/15) held in Bangkok from 18-20 April 2015 including the outcome of the Eleventh meeting of SEA/BOB ADS-B Working Group held in India from 17 to 19 November 2015. The report of meetings and other relevant documents are available on the following webpage: http://www.icao.int/APAC/Meetings/Pages/2016-ADS-B-SITF15.aspx
http://www.icao.int/APAC/Meetings/Pages/2015-SEA-BOB-ADS-B-WG11--.aspx

6.2 The ADS-B Implementation Status in the APAC Region updated by the Task Force is provided in **Appendix L** to this Report.

Development and achievements by the SEA/BOB ADS-B Working Group

6.3 Some developments and achievements since SEA/BOB WG/10 meeting were highlighted below:

- In May 2015, India and Myanmar signed MOU on ADS-B data sharing;
- In October 2015, Singapore and the Philippines signed an MOU to share ADS-B data and VHF facilities. The project is expected to be completed by early 2017;
- Brunei and Singapore started discussions on data sharing; the MOU is expected to be signed in 2016; and
- pdates on action being taken by Boeing mitigating ADS-B error from B787 fleet.

Regulator's Engagement in ADS-B Implementation

6.4 The meeting noted a lack of engagement by regulators in ADS-B implementation. Regulators need knowledge about the risks and benefits that ADS-B can bring to the safety of aviation. Nevertheless around the world, regulators seem slower than ANSPs to embrace the technology.

6.5 Importantly, the meeting considered that failure to deploy the safety improvements enabled by ADS-B could bring criticism and liability in the event of an adverse outcome. Whilst there are risks and mitigations required to deploy ADS-B, equally there are risks in doing nothing and continuing to rely on procedural ATC with its dependency on voice report of position. Accordingly, the meeting endorsed following Draft Conclusion:

<table>
<tr><td colspan="2">Draft Conclusion CNS SG/20 - C13: Regulators' active support and engagement with ADS-B Implementation and Data sharing</td></tr>
<tr><td>Considering that:-

a) any delay in ADS-B deployment and operational use brings risks, liability and additional regulator responsibility as traffic grows in FIRs without surveillance and automated safety nets; and

b) the risks in doing nothing whilst continuing to rely on ATC procedures with dependency on voice position reports and lack of automation

States (regulatory authorities) are urged to:

- actively engage with ANSPs to support the ADS-B implementation, in particular the examination of risks, hazards, mitigations and benefits; and
- support the ADS-B data-sharing and collaboration among States to achieve harmonized implementation for maximizing benefits of ADS-B.</td><td>Expected impact:
☒ Political / Global
☐ Inter-regional
☒ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
</table>

Why: lack of engagement by regulators in ADS-B implementation.	
When: September 2016 once approved by APANPIRG	Status: Draft to be adopted by PIRG
Who:☒Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐ Other:	

6.6 In response to a query, the Philippines advised that they were waiting for the completion of CNS/ATM project in later 2016 or early 2017 before planning ADS-B data sharing with neighbouring FIR.

System Specifications for developing an ADS-B Monitoring System

6.7 In following up an action item of the SEA/BOB ADS-B WG/11 meeting, Malaysia presented a working paper highlighting the result of a survey that proposed a checklist for monitoring the ADS-B system. The survey was distributed on 22 February 2016. Nine (9) States/Administrations responded to the survey, namely: New Zealand, Singapore, Japan, United States, India, Hong Kong-China, Thailand, Malaysia and Australia.

6.8 A checklist was developed based on the outcome of the survey picking up the most important common items/parameters for monitoring which are categorized into five main modules; Ground Station, Equipage, Avionics, Performance Level and ADS-B Display. The Ground Station module has three sub-modules, namely Site Monitoring, Remote Control & Monitoring and Logistic Support Monitoring. A checklist of options for developing an ADS-B monitoring system was considered useful. The updated checklist table agreed by the meeting was included in the revised AIGD.

Amendment to AIGD

6.9 The ADS-B SITF meeting identified the need to further update the AIGD based on the discussions on the information presented to the meeting. The consolidated amendment to AIGD is provided in **Appendix M** to this Report which includes the following:

- A checklist for monitoring of ADS-B system (revised table attached to WP/09);
- Additional functional requirements ADS-B Integration from HMI perspective for consideration, based on the contribution of the SEA/BOB ADS-B WG/11 meeting. Some editorial changes were made considering that general requirement should be considered rather than applicable to specific ATM system only (Appendix B to ADS-B SITF/15 WP/03 refers);
- Guidance on updating ADS-B ground stations to support Version 2 (DO 260B) based on the sample of DF17/DF18 Format Type Code 29 which have been changed significantly between versions (ADS-B SITF/15 WP/6 refers); and
- General recommendation on a technical solution of acquiring Mode 3/A code for DO-260 aircraft via Mode S downlink. (ADS-B SITF/15 WP/8 refers).
- Updated list of known ADS-B avionics problems in ADS-B SITF/15 Report Appendix 2 - Attachment A.

Accordingly, the meeting endorsed the following Draft Conclusion for consideration by APANPIRG:

<table>
<tr><td colspan="2">Draft Conclusion CNS SG/20 - C14: AIGD Amendment</td></tr>
<tr><td colspan="2">That, the consolidated amendments to the AIGD provided in Appendix M be adopted.</td><td>Expected impact:
☒ Political / Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="3">Why: provide guidance to States/Administration for ADS-B implementation</td></tr>
<tr><td>When: September 2016 once approved by APANPIRG</td><td colspan="2">Status: Draft to be adopted by PIRG</td></tr>
<tr><td colspan="3">Who:☒Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐ Other:</td></tr>
</table>

ADS-B Collaboration in the South China Sea Region

6.10 Singapore presented the developments of the ADS-B collaboration in the South China Sea region. Following the collaboration between Indonesia and Singapore and between Singapore and Viet Nam, the surveillance and DCPC gaps on L642, M771 and N892 are covered. The separation is now reduced to 30NM. A joint operational trial may be conducted with Viet Nam to assess the operational impact to reduce the separation to 20NM. Singapore will also work with Viet Nam and Malaysia to reduce separation on L625 and M758.

6.11 The Philippines and Singapore signed an ADS-B collaboration agreement in October 2015 to cover part of the surveillance gaps on routes N884 and M767. Discussions are on-going between Brunei and Singapore to cover the remaining gaps on N884 and M767. Singapore and Viet Nam are working on further collaboration to enhance the existing ADS-B coverage.

Implementation of ADS-B Avionics Problem Reporting Database (APRD)

6.12 The meeting noted the current status of the APRD development. ICAO Regional Sub Office in coordination with CAD Hong Kong China has developed testing site of the APRD. It was considered necessary to be hosted in ICAO APAC website as a project. The database still required some improvement. The meeting was also informed about the resource constraints in the ICAO Regional Sub Office. A number of States/Administration provided contacts of focal points for the operational testing including China, Hong Kong China, Indonesia, PNG and Singapore. Further follow-up action on this matter will be taken by SURICG.

6.13 In light of the resource constraints and the time being taken, the meeting agreed that the database should be started to use as soon as possible without waiting for it to be “perfect” or “fully functional”.

6.14 It was recalled that the Task Force had met 15 times in the past 13 years. A number of guidance materials in particular for the AIGD had been developed and then adopted by APANPIRG to assist States in the planning and implementation of ADS-B. Noting most of tasks set out in the Terms of Reference of the ADS-B Study and Implementation Task Force had been completed and the outstanding tasks and identified issues had been transferred to SURICG for consideration, the CNS SG endorsed the following Draft Decision:

<table>
<tr><td colspan="2">Draft Decision CNS SG/20 - D15: Dissolution of ADS-B Study and Implementation Task Force</td></tr>
<tr><td>That, the ADS-B SITF, having achieved the objective set out in its Terms of Reference, be dissolved.</td><td>Expected impact:
☐Political / Global</td></tr>
</table>

	☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: TOR for ADS-B SITF having been completed and the outstanding tasks and identified issues are transferred to SURICG which would cover broader surveillance technologies including ADS-B, SSR Mode S and Multilateration applications.	
When: September 2016 once approved by APANPIRG	Status: Draft to be adopted by PIRG
Who: ☒Sub groups ☐ APAC States ☐ICAO APAC RO ☐ICAO HQ ☐ Other:	

Note of appreciation

6.15 The meeting recorded its appreciation and gratitude to those States/Administrations which had hosted the ADS-B Task Force meetings and seminars in the past 13 years in particular, to Australia, Thailand, Fiji, India, China, Viet Nam, Indonesia, Singapore, Republic of Korea, Hong Kong China and New Zealand. The meeting thanked participants form States/Administrations, International Organizations and representatives from Industry for their active participation in activities of the Task Force and contribution to the achievements and outcome of the Task Force.

6.16 The meeting noted that in appreciation for their contribution, Mr. Arun Mishra, ICAO Regional Director presented memento plaques to Mr. Greg Dunstone, the Chair of ADS-B Study and Implementation Task Force for his able leadership; to CAA. Singapore for its contribution towards the development of the modernized regional Surveillance infrastructure and promotion of data sharing in the South China Sea sub-region and to CAD Hong Kong China for its contribution to the development of the ADS-B Implementation and Operation Guidance Document (AIGD) for the APAC Region.

Report of First Meeting of the Surveillance Implementation Coordination Group (SURICG/1)

6.17 The First Meeting of the Surveillance Implementation Coordination Group was held in Bangkok, Thailand, from 21 to 22 April 2016. The report of meeting and other relevant documents are provided on the following ICAO APAC webpage:
http://www.icao.int/APAC/Meetings/Pages/2016-SURICG1.aspx

Election of Chairpersons

6.18 Nominated by Cambodia and seconded by New Zealand and Fiji, Mr. Hui Man Ho, Chief Electronics Engineer of the Civil Aviation Department of Hong Kong China, and Mr. Alex Milns, Chief Operating Authority – Surveillance, Airservices Australia were unanimously elected as co-chairs of the SURICG.

Information from Aeronautical Surveillance Working Group of the ICAO Surveillance Panel

6.19 The meeting noted the relevant outcomes of the Third Meeting of the Aeronautical Surveillance Working Group of the Surveillance Panel (SP-ASWG) held in London from 11 to 14 April 2012. The meeting considered that the information at global level which were relevant for the work programme of SURICG at regional level. Such information would avoid duplicated efforts at regional level and may contribute from APAC Region to the work at global level. The meeting also noted the future meetings schedule of ASWG. Noting that Australia, China, Japan and Singapore have been active participants at different times in the ASWG meetings, the meeting encouraged participants from APAC Region to contribute to the work and study at global level. Australia also encouraged APAC States/Administrations to participate in the work of RTCA.

Surveillance Strategy for the Asia/Pacific Region

6.20 The SURICG/1 meeting reviewed the Surveillance Strategy for the Asia/Pacific Region adopted by APANPIRG/24 in June 2013 and the proposed amendments at the CNS/SG/19 meeting in July 2015. The meeting established an ad hoc working group with members from Australia, Hong Kong China, New Zealand, Singapore, USA, Viet Nam and IATA for consolidating all proposed changes.

6.21 The meeting agreed to the revised regional surveillance strategy with all consolidated changes recommended by the SURICG and endorsed the following Draft Conclusion:

Draft Conclusion CNS SG/20 - C17: Revised Surveillance Strategy for the APAC Region	
That, the revised surveillance strategy for the APAC Region provided in **Appendix N** to the Report be adopted.	Expected impact: ☒ Political / Global ☒ Inter-regional ☒ Economic ☐ Environmental ☒ Ops/Technical
Why: provide guidance to States/Administration for implementation of Surveillance service	
When: September 2016 once approved by APANPIRG	Status: Draft to be adopted by APANPIRG
Who: ☒Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐ Other:	

Actions Items referred to SURICG by ADS-B SITF

6.22 The meeting noted the initial list of task/action items referred to SURICG by ADS-B SITF (both list of outstanding issues and action items). The meeting also noted that SURICG considered it necessary to establish a working group to investigate the wider application of Mode S technology in the Asia/Pacific Region.

Date and venue for the next meeting of SURICG

6.23 The meeting noted that next meeting of SURICG meeting would be held in Mongolia in early June 2017. The duration of the meeting would be 4 or 5 days including one day seminar on Mode S technology. The meeting appreciated the offer from Mongolia to host the SURICG/2.

ADS-B implementation in Mongolia (IP/03)

6.24 Mongolia provided an information paper on the current and planned implementation of ADS-B. Mongolia has intention to mandate ADS-B equipage on certain routes by 2018. Currently CAAM installed 10 ADS-B stations along the main en-routes. They have been used for situation awareness since March 2016. It was observed that 93% of flights over Mongolian airspace are equipped with ADS-B. By 2017, additional 5 stations will be in operational.

Australia’s ongoing ADS-B implementation programme (IP/10)

6.25 The meeting noted the ongoing ADS-B implementation programme in Australia. Mandate for ADS-B equipage of all IFR aircraft will be effective from 2nd of February 2017. The

Australian aviation industry is making good progress – the following statistics apply to Australia-registered IFR aircraft with ADS-B equipage:

- 100% of flights (100% of aircraft) operated by major airlines above FL290
- 94% of flights (87% of aircraft) operated by business jets above FL290
- 98% of flights (96% of aircraft) operated by turboprops above FL290
- 99.9% of flights (95% of aircraft) operating 500NM north and east of Perth
- 81% of flights (62% of aircraft) of all IFR for all levels

6.26 Beginning April 2017, Airservices Australia will decommission three of its en-route surveillance radars and ADS-B will be used instead.

ADS-B Performance Monitor Application (IP/21)

6.27 Indonesia presented information on their efforts to monitor ADS-B Tier 1 implementation within Indonesian FIR. Actions have been taken to ensure ADS-B implementation to meet the baseline parameters. The monitoring systems were developed “in house”, using local expertise, and making reference to the information on similar systems in Australia. The configuration of ADS-B Performance Monitoring Tools was introduced in the paper. The tool will be installed at ATC Supervisor and Engineer Supervisor position at both Jakarta Air Traffic Services Center (JATSC) and Makassar Air Traffic Services Center (MATSC). Indonesia invited other States to collaborate in the monitoring of Tier 1 ADS-B performance to acknowledge the benefits and ensuring safety deliveries.

Status of ADS-B Implementation in the USA (IP/13)

6.28 USA provided an update on the status of its ADS-B implementation activities. The RTCA Program Management Committee approved DO-328A and DO-361, the Safety, Performance and interoperability Requirements (SPR) and MOPS for Flight-deck-based Interval Management (FIM), respectively, on 22 September 2015. The FAA Flight Standards Service has determined that no operational approval is required for aircraft with avionics compliant with FAA AC20-165 to operate in U.S. airspace defined in Title 14 of the Code of Federal Regulation (14 CFR) § 91.225 (part of the U.S. ADS-B Final Rule). AC 90-114A provides users of the NAS guidance on a means of conducting flight operations. AC 90-114A, Change 1 published on 7 March 2016 contains some significant changes from the previous version of the AC: revised equipment qualification resulting from a technical amendment to U.S. 14 CFR 91.225 and details for installation approval.

6.28.1 Considering the amendments or changes having made to FAA’s ADS-B provisions, the references to FAA AC numbering in the SUPPs Doc.7030 and mandate template adopted by APANPIRG need to be updated accordingly. SEA/BOB Sub-regional ADS-B Implementation Working Group is therefore requested to review relevant regional guidance document at its next meeting and make recommendations on changes required.

FAA Exemption 12555 (IP/14)

6.29 Exemption 12555 is a time-limited grant of exemption from the Navigation Integrity Category (NIC) and Navigation Accuracy Category for Position (NACp) requirements specified in Title 14 of the U.S. Code of Federal Regulations (CFR). Exemption 12555 is valid from January 1, 2020 through December 31, 2024 and is subject to certain conditions and limitations. Exemption 12555 is intended for operators of aircraft with GPS receivers (position sources) compliant with the current edition of FAA Advisory Circular (AC) 20-165, Airworthiness Approval of Automatic Dependent Surveillance –Broadcast Out Systems, Appendix B, Identifying and Quantifying ADS-B Position Sources. The exemption is not limited to U.S. registered aircraft. The process for obtaining

Exemption 12555 is provided in the paper. The conditions and limitations of Exemption 12555 are detailed in the Grant of Exemption:
https://www.regulations.gov/#!documentDetail;D=FAA-2015-0971-0010 .

Implementation of Multilateration in Republic of Korea (IP/11)

6.30 Republic of Korea plans to install Multilateration (MLAT) to supplement the existing surveillance system at Incheon International Airport (IIA). 30 ground stations will be installed by December 2016 as phase one and additional 5 units will be installed by August 2017 as phase two.

6.31 AIP supplements have been recently updated to notify the operators that Mode S transponder needs to be switched on during aircraft movement on the airfield. This would enable detection and identification of the aircraft as soon as it pushes back. Pilots are required to ensure that Mode S transponder are fully operational when aircraft is on the ground (Do not select off or STDBY function). Pilots should also keep mode A code assigned by ATC. IFALPA informed the meeting that some aircraft could not keep the transponder during push-back unless its first engine had started. It was further clarified by Korea that such procedure would be effective from June 2016.

USE of Mode S DAPS SFL and QNH Data (IP/11 (SURICG) & IP/17)

6.32 New Zealand provided information on implementation of Mode S DAPS, specifically Selected Flight Level within the Air Traffic Management System.

6.33 The intent of this enhancement is to provide controllers with a "Selected Flight Level" (SFL) data extracted from aircraft equipped with Mode S Enhanced Surveillance transponders (EHS). The selected altitude is available from BDS Register (4,0) and is interrogated every 20 seconds by Airways MODE S radars and the Multilateration system or alternatively downlinked from ADS-B equipped aircraft with DO260A or DO260B transponders. The extracted data enables the Air Traffic Management system (ATMS) to generate a safety alert when the SFL chosen by the crew DOES NOT match the cleared altitude given by the controller, alerting the controller to take appropriate action to remedy the issue.

6.34 New Zealand updated CNS SG/20 that the project of introduction of MODE S DAPS data (specifically Selected Flight Level (SFL)) into its Skyline Air Traffic Management System was completed in May 2016 with the software going live on the night of 25 May 2016. On the first day of operation the use of SFL alerting stopped a possible loss of separation by indicating the crew had selected an altitude below their cleared level, which in this instance was occupied by other traffic. The Airways has begun on extracting DAPS QNH data to provide alerts to controllers when an incorrect QNH value is set by a flight crew. This initial worked commenced in late March 2016. DAPS QNH data extracted from BDS register (4,0) is intended to provide controllers with an alert when required. New Zealand noted a number of aircraft did not correctly report QNH DAPs data above the transition level. Such issues and applications should be further discussed at SURICG.

Requirement for ACAS/TCAS v7.1 equipage (IP/15)

6.35 Through the information paper, the Secretariat reminded CNS SG/20 about the requirement for ACAS upgrading to ACAS/TCAS Version 7.1 from 1 January 2017. ICAO APAC Regional Office issued a letter of reminder with queries on status of implementation of the requirement by the States/Administrations. The deadline of response to the State Letter is 8 August 2016. States were urged to convey the reminder to their Administrations for timely response.

6.36 The requirement as an ICAO Standard for mandatory equipage with ACAS V7.1 was resulted from the amendment 85 to Annex 10 Volume IV which became applicable on 18 November 2010. The standard requires forward fit for TCAS/ACAS II V 7.1 equipage by 1st January 2014 and by 1 January 2017 for retrofit (sections 4.3.5.3.1; 4.3.5.3.2 and 4.3.5.3.3 in Annex 10 Vol. IV refers).

Interim Report of APAC/NAT Inter-regional ADS-C RITF (IP/04)

6.37 The meeting noted the interim report of ICAO APAC/NAT Inter-regional ADS-C Reporting Interval Task Force. The first meeting of the Task Force (ADS-C RITF/1) was held from 21 to 23 June 2016 in the ICAO EUR/NAT Office Paris, France. A few teleconferences were held before the first meeting of the Task Force. The outcome of the first meeting is highlighted in the **Appendix O** to the Report.

6.38 The meeting noted the following conclusions by the Task Force:

a) Better understand the sensitivities to system loading based on ADS-C reporting intervals. The key sensitivities are:

i. for SATCOM, how each channel is utilised and loaded in the global beam;

ii. for VHF, RF channel capacity for plain old ACARS stations located in oceanic transition areas;

iii. For ANSP, the impact of the increased reporting rates on system design;

iv. For airspace users and aircraft manufacturers, the impact on avionics.

b) Determine a minimum ADS-C periodic reporting interval that would be technically feasible under specified conditions without significantly impacting operational performance;

- The answer is dependent on the concepts of operation at regional, ANSP and AOC levels. Based upon the concepts discussed by the ADS-C RITF, provided ICAO Doc 10037 and ICAO Circular being developed includes requirements and guidance for ANSPs, regional groups, and airlines on planning, coordinating and implementing new operational concepts and requirements for reduced separation standards and higher periodic reporting rates, then:

i) For the current Classic/VHF datalink system:

– Tree minutes are feasible, if needed, to support a new separation standard at RSP 180, with an understanding that, based upon the ANSP and AOC operational concepts or requirements: if widely used, financial impacts may be incurred to support additional system capacity;

– 64 second are feasible on an exception basis for abnormal/distress reporting: if used more widely, financial impacts may be incurred to support additional system capacity.

ii) For the SwiftBroadband-Safety (SB-S) system over oceanic and remote airspace:

– Two minutes are feasible to support a new separation standard at RSP 180, with an understanding that, based upon the ANSP and AOC operational concepts or requirements: if widely used, financial impacts may be incurred to support additional system capacity;

– 64 second is feasible on an exception basis for abnormal/distress reporting: if used more widely, financial impacts may be incurred to support additional system capacity.

iii) i) above is based on experience of operation of current systems. ii) is an assessment of the evolving future system supported by expanding on the experience of a), theory, and data from on-going evaluations. The effect of reporting intervals below 2 minutes on avionics performance needs to be assessed.

c) Determine benefit to the regions in their planning and implementation of future ATM concepts of operation (e.g., NAT Service Development Roadmap and future 2025 concept of operations).

- New SATCOM systems provide new methods for providing position reporting that do not employ ADS-C. These position reports can be streamed at high rates to ground systems. Some of these systems are planned for deployment in the near term.

d) Support validation of future standards for applying minimum separation based on ADS-C, such as 37 km (20NM) longitudinal separation minimum, currently under development by the Separation and Airspace Safety Panel (SASP).

6.39 The Meeting noted the further actions to be taken by the ADS-C RITF:

a) Provide this meeting report as an interim ADS-C RITF report to NAT SPG/52 and APANPIRG in 2016;

b) Develop draft amendments to Doc 10037 by September 2016 for consideration by the NAT Technology and Interoperability Group (TIG) and OPDLWG;

c) Provide a final report to APANPIRG in September 2017 and NAT SPG/53 in June 2017;

d) Provide input material to the ICAO SASP in September 2016;

Agenda Item 7: Aeronautical electromagnetic spectrum utilization

Outcome of WRC-2015 and preparation for WRC-2019 (WP/13)

7.1 The Secretariat presented the results of the International Telecommunication Union (ITU) World Radiocommunication Conference 2015 (WRC-15) held from 2 to 27 November 2015, in Geneva, Switzerland. In general the conference results fully conformed to the ICAO Position. The paper also recalled the significant efforts made by ICAO and member States in preparations for WRC-15 including the regional preparatory activities. The results of the conference on all agenda items relevant to aviation are provided in Appendix A to the paper and Appendix B contains a copy of the Radioregulatory text developed to solve agenda items 1.5, 9.1.5 and Global Flight Tracking, including the Resolution describing an aeronautical agenda item for WRC-19 on the Global Aeronautical Distress and Safety System (GADSS). The meeting expressed gratitude to those States/Administrations who had actively supported ICAO position during period of preparation and at WRC-2015 itself.

7.1.1 An expeditious start of the ICAO preparatory activities for the next conference in 2019 is now essential.

7.1.2 The Frequency Spectrum Management Panel (FSMP) WG/3 meeting is scheduled to be held at ICAO Headquarters in Montreal from 6 to 14 September 2016. Among the tentative agenda items, completion of ICAO Position for WRC-19 is listed as agenda item 2.

7.1.3 The 1st Meeting of the APT Conference Preparatory Group for the WRC-19 (APG19-1) will be held from 26 to 28 July 2016 in Chengdu, People's Republic of China. The meeting will be organized by the Asia-Pacific Telecommunity (APT) and hosted by the Ministry of Industry and Information Technology of China.

7.1.4 States and International Organization concerned were urged to actively participate in the national preparatory activities at national, regional and global level. Those member states of FSMP from APAC Region (Australia, China, India, Japan and Philippines) are strongly encouraged to actively participate and provide contributions on the development of ICAO position from APAC's perspective.

7.1.5 States were also invited to nominate and/or reconfirm contact points for WRC-19 and inform ICAO APAC Office about their contact details. States should also be urged to support ICAO position at appropriate forums at national, regional and global level. ICAO should consider conducting regional preparatory group meetings in 2017 and/or 2018 once ICAO position approved by ICAO Council is released. In view of the foregoing, meeting endorsed the following Draft Conclusion:

<table>
<tr><td colspan="2">Draft Conclusion CNS SG/20 - C18: Preparations for International Telecommunication Union (ITU) World Radiocommunication Conference 2019 (WRC-19)</td></tr>
<tr><td>That,
a) States be urged to:
- nominate/reconfirm Contact Focal Points for WRC-19 and inform ICAO APAC Office about their contact details;
- consider national and international requirements for aeronautical services identified in Agenda of WRC-19 and develop national positions in line with ICAO Position to ensure the availability and protection of aeronautical spectrum;
- support ICAO position for WRC-19 at national and international meetings including APT Preparatory Group for WRC-19.

b) ICAO be invited to conduct regional preparatory group meetings for WRC-19 in 2017/2018.</td><td>Expected impact:

☒ Political / Global
☒ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="2">Why: Require to protect aeronautical spectrum and support ICAO position during preparation phase for and at ITU WRC-2019</td></tr>
<tr><td>When: September 2016</td><td>Status: Draft to be adopted by PIRG</td></tr>
<tr><td colspan="2">Who: ☒Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☒APANPIRG ☐ Other:</td></tr>
</table>

Report of SRWG/3 meeting (WP/14)

7.2 The meeting was informed about the outcomes of the SRWG/3 meeting held from 31 May to 02 June 2016 in Thailand and necessary follow-up work to be conducted. The meeting was reminded that Conclusion APANPIRG/26/47 adopted in 2015 invites States to submit and update their operational needs in terms of VHF frequencies (international and national) on a yearly basis to the ICAO Regional Office.

7.2.1 The most significant outcome of SRWG/3 was that no congestion of VHF frequencies was expected in the next 5 years in APAC Region, subject to new simulation in 2017-2018 if operational needs were significantly amended. Simulation results obtained by India would allow India to meet their operational needs, provided that the frequencies may be found outside frequency pools (as defined by ASIA/PAC/3/RAN Meeting Conclusion 11/4), which is in line with the Volume II of ICAO Doc.9718 and implemented by Frequency Finder. The meeting discussed that with the expected growth in traffic, national planning of frequencies should take care of the increasing probability of simultaneous transmissions. The subject could be further discussed at SRWG/4.

7.2.2 As a follow-up to APANPIRG Conclusion 26/48 and with respect to conclusion bullet (a), the meeting was informed that ICAO HQ had secured resources to implement and maintain the global Frequency Finder tool.

7.2.3 Regarding bullet (b) of the same Conclusion, a workshop on Frequency Finder is tentatively scheduled in the week of 17 to 21 October 2016 in Bangkok, Thailand; duration still to be determined (3 to 5 days). All States/Administrations were invited to note the date.

7.2.4 It was reminded that the action for States to check consistency between global database and frequency list 3 remains open and extended to 14 October 2016 in order to reconcile databases to the greatest extent possible before the workshop.

VHF voice service over high platform (IP/23)

7.3 Through IP/23, Singapore made a proposal for the potential VHF voice services through High Altitude Platforms or low Earth Orbit Satellites. In order to provide radar-like or other reduced separation services, both appropriate surveillance and communications are required.

7.3.1 Not like space based ADS-B, there is currently no ready solutions to provide VHF voice services over oceanic and remote areas. One possible solution would be space-based VHF voice communications, whereby VHF radio relay equipment will be mounted onto Low Earth Orbit (LEO) satellites to relay air-ground communication. It is expected that the solution will work with all existing civil aircraft which are equipped with VHF radio voice communications equipment.

7.3.2 Another possible solutions would be using high-altitude platforms such as balloons or un-manned aerial vehicles hovering at up to 100,000 feet above mean sea level. Likewise, it is expected that the solution will work with all existing civil aircraft which are equipped VHF radios. Some of the challenges of this solution are:

a) Interference to other adjacent VHF radio stations using the same frequencies, as the footprints of the platforms will be much larger than the coverage of ground-based VHF radios, although to a lesser extent as compared to space-based VHF;

b) Logistics and resources to keep the platform in place; and

c) Ensure that VHF frequencies were protected up to 100,000 feet.

7.3.3 It was recognized that there are still substantial studies to be conducted. There is also a need to understand whether the aeronautical VHF frequency band are or can be protected for civil aviation use in the operating airspaces (e.g. whether ICAO/ITU can allow trials on and/or operations of space-based VHF). These need to be established as soon as possible so that studies and trials can be conducted.

7.4 The Secretariat advised that since the footprints of the platforms will be much larger than the coverage of ground-based VHF radios which would cross over a number of States /Administrations, therefore a modification to the ITU RR would be needed. Also necessary provisions for Annex 10 Vol. V and Doc 9718 Vol II for this should also be considered. It was recommended that Singapore should bring a paper with more detailed information to the attention of the Frequency Spectrum Management Panel (FSMP). If only for functional testing, temporary frequency could be allocated as a regional support for a potential solution to overcome the communication difficulties in remote and oceanic areas as long as there are no issues with adjacent Regions. The result of functional testing will be presented to FSMP for their information.

Agenda Item 8: Review and updates

8.1 **Seamless ATM Reporting and regional picture (WP/15)**

8.1.1 The meeting reviewed the information from the Seamless ATM Reporting and Monitoring System. ICAO had only had about 57% of expected reports, so drawing conclusions on incomplete data was difficult. Nevertheless, of the ten priority elements, only one (B0-TBO: ADS-C/CPDLC) was confirmed as appropriately implemented, with seven having only partial implementation and two poor implementation (B0-DATM: Digital Aeronautical Information Management and B0-ASUR: ADS-B). The material can be found here: http://www.icao.int/APAC/Pages/ATMReport.aspx

8.1.2 The meeting was informed that a paper would be presented to DGCA to emphasize the need for resource mobilization about the ten priorities.

Seamless ATM plan update (WP/10)

8.1.3 Secretariat presented the proposed changes to the Asia/Pacific Seamless ATM Plan 2016. The main updates are highlighted to guide APAC States/Administrations in their review. In addition, a formal consultation is organized by State Letter to circulate the draft version of the Seamless ATM Plan update (with input from the ATM/SG and CNS/SG) to all Asia/Pacific States, with a cut-off for comment by 22 August 2016 for a potential adoption by APANPIRG in September 2016. Essentially the new items introduced with target date of implementation for 2019 are:

- B1-ACDM;
- B1-SURF;
- B1-RSEQ;
- B1-CDO;
- B1-TBO (only Datalink Clearance - DCL);
- B1-NOPS;
- B1-SAR;
- Human-performance-language proficiency;
- Ballistic rocket launch/space re-entry management planning;
- Voice communications over IP between ATS units (VoIP);
- Common aeRonautical Virtual private network (CRV) and
- Airport Master Plans.

8.1.4 Hong Kong China stated that from past experience in formulating the 1st version of Seamless ATM Plan back in 2013, it took four dedicated meetings of APSAPG for States to go through and agree the entire Plan after States acquiring thorough understanding of the plan. It is noted that States are requested to provide feedback on the revision of the Seamless ATM Plan by 22 Aug 2016. Considering there are quite a number of changes in this revision involving more advanced/new modules and changes in priorities under ASBU Block 1, Hong Kong China suggested ICAO to consider organizing a workshop to steer States to better understand and gear up the new changes, what actions States need to take in order to meet the new requirements, sharing their difficulties and experience, regular updates of dashboard. Most importantly, to get consensus and solicit greater support among States, and expediting their efforts to this revised Plan. The recommendations were also supported by China and USA. ICAO was requested to conduct a workshop on the updated Seamless ATM Plan after it is adopted by APANPIRG.

8.2 **Review TOR of contributory bodies (Task Forces & Working Groups) (WP/16)**

8.2.1 In accordance with *Decision APANPIRG/26/66*, the meeting reviewed TORs and their current status of those contributory bodies that report to APANPIRG through CNS SG of APANPIRG. The meeting noted that ADS-B SITF and ISTF have been proposed for dissolution.
The meeting did not identify the need to amend the TOR of the rest contributory bodies that report to the CNS SG except the reporting path of SEA/BOB Sub-regional ADS-B implementation working group needs to be changed to Surveillance Implementation Coordination Group from ADS-B SITF. This change should be made by the working group at its next meeting in November 2016.

8.2.2 TOR for ACSICG, PBNICG and SURICG had been proposed for changes by the individual groups which were endorsed by the CNS SG. The Draft Decisions (SG/20-D2; SG/20-D6 and SG/20-D16) formulated by contributory bodies on the revised TORs of ACSICG, PBNICG and SURICG are consolidated into a single draft Decision for consideration by APANPIRG.

<table>
<tr><td colspan="2">Draft Decision CNS SG/20 – Dxx - (D2/D6/D16): Revised TOR of Aeronautical Communication Services Implementation Coordination Group – (ACSICG); Performance Base Navigation Implementation Coordination Group (PBNICG) and Surveillance Implementation Coordination Group (SURICG).</td></tr>
<tr><td>That, the Revised Terms of References of ACSICG, PBNICG and SURICG provided in Appendix C be adopted.</td><td>Expected impact:
☐ Political /Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="2">Why: Result of review according to APANPIRG Decision 26/66</td></tr>
<tr><td>When: September 2016</td><td>Status: Draft to be adopted by PIRG</td></tr>
<tr><td colspan="2">Who:☒Sub groups ☐APAC States ☐ICAO APAC RO ☐ICAO HQ ☒APANPIRG ☐ Other:</td></tr>
</table>

Hong Kong new ATM system (WP/21)

8.3 Hong Kong, China informed the meeting about its progressive transition approach known as Phased Functional Implementation (PFI) to launch the new ATC System incrementally from June 2016 onwards. It was reported that the use of the new ATC System was progressively expanded in terms of operating time and the scope of service coverage over a period of about five months. Subject to actual experience and progress, the new ATC System was expected to be fully commissioned and operated by October/November 2016. The meeting found the lessons learnt instructive and as Hong Kong China reported that sufficient time should to be allocated to personnel for them to adapt to the new working environment and relieve pressure over an extended period of transition. The meeting agreed to encourage States/Administrations concerned to provide full support to Hong Kong China to exercise both strategic and tactical ATFM measures if applicable during complete E-ATCC transition in October or November 2016.

Cybersecurity measures (WP/22)

8.4 Hong Kong China informed the meeting about the key elements of an effective cyber security management framework for a safe and secured ATC system as well as the latest status achieved by Hong Kong, China in pursuing the ICAO's ATM Cyber Security Manuel published in 2013.

8.4.1 Considering the transversal nature of cybersecurity, the meeting decided to include a specific agenda item in the standing agenda of CNS SG regarding cybersecurity from CNS SG/21 onwards. States/Administrations were urged to provide contributions on this subject to share their experience and lessons learnt.

8.4.2 To address the growing concerns on cyber security threats, ICAO published Doc 9985 "ATM Security Manual" in 2013 setting out the principles and guidelines for protecting ATC system infrastructure. States/Administrations were urged to follow the principles and guidelines for protecting Air Navigation Systems and services. ICAO was requested to conduct workshop or seminar to promote its implementation.

Agenda Item 9: Review status of CNS deficiencies (WP/17, WP/29 & IP/22)

9.1 The related outcome of discussion is consolidated into the working paper on Deficiency and the updated list of air navigation deficiencies in CNS fields is provided in the **Appendix P** to the meeting Report.

Agenda Item 10: Human Factors and Air Traffic Safety Electronics Personnel (ATSEPs) related training

Development of ATSEP Training in southwest ATMB of China (WP/24)

10.1 China presented information on the training organization for ATSEP available at its Training Center of Southwest ATMB established in March 1997 which is the first approved Aeronautical telecommunication personnel training organization in China. The training, delivered by 65 full-time and part-time coaches and instructors, is structured according to Basic training, Qualification training, Continuation Training and Developmental Training. The paper also introduced the items of training, supporting facilities, system & equipment used for the training and syllabus & teaching materials provided by the training center.

10.1.1 The meeting congratulated China on their development of ATSEP training. Hong Kong China also mentioned that CAD has adopted a competence assurance scheme for its Electronics Engineers in accordance with the training requirements of ICAO PANS-Training for ATSEP. In parallel, the CAD's maintenance service providers (MSP) responsible for operation and maintenance of CNS/ATM equipment has also implemented a competency-based ATSEP scheme to support the safety–critical CNS/ATM equipment operations. CAD has gone one step further in steering the Hong Kong Institution of Engineers (HKIE) to accredit the ATSEP training scheme, such that ATSEP certified personnel are accredited to become Associate Members of the HKIE. This will greatly facilitate the technical staff of NGAP to pursue professional qualification and career development in the aviation discipline.

Competency-based training for ATSEPs (IP/18)

10.2 Secretariat introduced amendment 4 to PANS TRG, along with ICAO Doc 10057 (Manual on Air Traffic Safety Electronics Personnel Competency-based Training and Assessment) which respectively contain procedures and guidance for the development and implementation of a competency-based training programme for the Air Traffic Safety Electronics Personnel (ATSEP). A workshop related to ATCO and ATSEP competency-based training and assessment was organized in Montreal (ICAO state letter AN 21/3-16/41), from 28 to 30 June 2016. The objective was to roll out the framework of PANS-TRG and help the understanding on how to implement it using the two new specific manuals, show the advantages of CBT over conventional training methodologies and how to adapt current and future training.

10.2.1 The meeting agreed that such a workshop would be beneficial in APAC Region in 2017 and endorsed the following Draft Conclusion:

<table>
<tr><td colspan="4">Draft Conclusion CNS SG/20 - C19: Workshop on competency-based training and assessment for the Air Traffic Safety Electronics Personnel (ATSEP)</td></tr>
<tr><td colspan="3">That, a workshop addressing ATSEP competency-based training and assessment be organized in 2017 (or 2018) in APAC Region.</td><td>Expected impact:
☐ Political / Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td colspan="4">Why: ATSEP have a key role in the safety chain of ANSP, and a workshop on competency-based training will improve the know-how of the States/ANSP to efficiently build their training.</td></tr>
<tr><td>When:</td><td>20-Dec-17</td><td>Status:</td><td>Draft to be adopted by PIRG</td></tr>
<tr><td>Who:
Other:</td><td colspan="3">☐Sub groups ☒APAC States ☒ICAO APAC RO ☒ICAO HQ ☐</td></tr>
</table>

Agenda Item 11: Dates of next meeting and any other business

Amendment to APANPIRG Procedure Handbook (WP/26)

11.1 The meeting noted the amendments that would be introduced to the 4th Edition of the APANPIRG Procedural Handbook consequent to the approval of the new structure of APANPIRG, revised Terms of Reference of Sub Groups, Project Management Principles, Procedures to be followed for the processing of Sub Group endorsed Conclusions and Decisions and coordination mechanism principles for RASG and PIRG. The members States/Administrations were encouraged to review the proposed changes provided in the Attachment to the paper and provide any comments to the APANPIRG/27 when the amendments are accepted.

Standardization of Operational Trials in Oceanic Airspace (IP/02)

11.2 Through the information paper, USA promoted awareness of the U.S. objectives for the upcoming 39th Session of the ICAO Assembly (A39) by sharing applicable U.S. Working Papers with the CNS Sub-Group.

11.3 Well-designed operational trials are critical to the successful implementation of new Air Traffic Management (ATM) procedures. They are used to demonstrate a practice, to acquire operational performance data, to expose participants to potential changes in operation, and to test the viability of one or more sub-systems that are critical to a new ATM procedure. Trials conducted over oceanic/high seas airspace have produced measurable gains in capacity and efficiency. However, operational trials are also associated with elevated risk and generally involve special training, software and equipment. At any one time, multiple trials may be ongoing in oceanic airspace around the globe. A single aircraft can be subject to more than one trial in a single journey, but there is no ICAO guidance to govern their conduct. To ensure that primary safety considerations are addressed in the design and execution of operational trials, ICAO and States were invited to consider developing guidance to standardize the planning and implementation of operational trials in oceanic airspace.

Areas of Interest to USA at the 39th ICAO Assembly (IP/05)

11.4 The meeting noted an overview of areas of interest for the United States at the 39th ICAO Assembly and aviation challenges for the next Triennium highlighted in the paper.

Status Update on the Long-Term Vision for CARATS (IP/06)

11.5 Japan presented the information about status update of the long-term vision for the future air traffic systems in Japan, namely “CARATS: Collaborative Actions for Renovation of Air Traffic Systems”. Through CARATS, Japan has steadily achieved the improvement of air navigation services in order to cope with the growth in global air traffic demand in the future and to contribute to address various issues in the APAC Region. Further information on the progress of CARATS can be obtained from the following website: http://www.mlit.go.jp/koku/koku_CARATS.html

Dates of next meeting

11.6 The meeting agreed that next meeting of the CNS Sub-group (CNS SG/21) would be scheduled for 10 to 14 July 2017 in ICAO APAC Regional Office, Bangkok, Thailand**.**

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ATN/AMHS/AIDC Implementation Status in the APAC Region

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
AFGHANISTAN					
AUSTRALIA	ATN tests were conducted. BIS Router and Backbone BIS Router and AMHS implemented. 64 kbps IPLC established with Fiji. Basic AMHS circuit will be commissioned in September 2014; Another basic AMHS circuit planned for operational in May 2016.	COMSOFT	AFTN based AIDC Implemented between Brisbane and Melbourne, Oakland, Nadi and Auckland; Implemented between Melbourne and Johannesburg; AIDC is also in use between Melbourne and Mauritius; Operational trial between Brisbane and Ujung Pandang since May 2013.		

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
BANGLADESH	In Q1/2013, Bangladesh installed ATN/AMHS and BIS Router at Dhaka (VGHS) with User Agents at Chittagong (VGEG) and Sylhet (VGSY).	COMSOFT	Tentative date of implementation of AIDC is Q4 of 2018 with Kolkata and Myanmar.		The Bangladesh ATM Upgrade Project (BATMUP) under Public Private Partnership (PPP) in Dhaka is expected to be completed by 2018. As soon as the ATM up-gradation is completed hopefully Bangladesh will be able to implement AIDC with Kolkata and Myanmar by the end of 2018.
BHUTAN	ATN BIS Router and UA service planned for 2015.				
BRUNEI DARUSSALAM	ATN BIS Router planned for 2015 and AMHS planned for 2015				

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
CAMBODIA	BIS Router and AMHS installed. Cambodia (CATS) AMHS connected with Bangkok via VSAT IP link on 10 December 2013	AVITECH	AIDC function and capability made available. Ready for testing with neighbors ATS Facilities starting from 2015-2016.	THALES which supports AIDC ICD Version 1.	
CHINA	ATN Router and AMHS including NCC deployed in 2008 which is being upgraded to support ATN/IPS with target date of completion in December 2013. Tripartite BBIS trial completed with Bangkok and Hong Kong, China in Jan. 2003. ATN trial with Hong Kong using XOT over internet conducted in 2006, Further trials conducted in 2009. Plan for ATN/AMHS implementation with Hong Kong, China (2016). AMHS/ATN technical tests with Macau completed in 2009. Plan for ATN/AMHS implementation with Macau, China (2016). ATN/AMHS circuit with ROK put into operational use since June 2011. ATN/AMHS tests with India started from March 2011 using 64 Kbps landline. Plan for operational use in Q2016. ATN and AMHS technical trial with Mongolia is TBD.	IN-HOUSE (Aero-Info Technologies Co., Ltd)	AIDC between some of ACCs within China has been implemented. AIDC between several other ACCs are being implemented. AIDC between Sanya and Hong Kong put in to operational use since 8 Feb 2007. AIDC between Qingdao and Incheon planned for 2015; Implemented between: Guangzhou with Nanning/Zhanjiang/Zhuhai; Nanning and Kunming/Guiyang/Zhanjiang in 2011; Zhanjiang/Haikou; Chengdu and Chongqing/Guiyang in 2011; Guiyang and		

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
	Interoperability test with Thailand is completed over internet. Connection tests with Nepal is TBD		Chongqing/Kunming in 2011; Started negotiation for implementation between Dalian and Incheon and Shanghai/Fukuoka.		
HONG KONG, CHINA	Preliminary ATN/AMHS technical trials with China (Beijing) using VPN over Internet connection in 2006. Operational AMHS and BIS router accepted in July2009. ATN/AMHS circuit with Macao put into operation use in Dec. 2009. ATN/AMHS circuit with Bangkok put into operation use in Sept. 2014 ATN/AMHS interoperability tests with other adjacent communications centres commenced in late 2009, viz Taibei (2009), Japan (Planned Q4/2017), Philippines (Planned Q1/2017) and Viet Nam (Planned Q1/2017) Pre-operational trial will be conducted in Q3 2016 before the ATN/AMHS put into operation with China (Beijing) in 2016.	COMSOFT	AFTN-based AIDC with Sanya put into operational use in Feb 2007. AIDC trial with other adjacent ATS authorities for new ATC system to be commissioned by Q4/2016. AIDC technical trial with Taibei conducted in 2010 and completed in 2012 and put into operational use in Nov. 2012 AIDC technical tests with Guangzhou and Manila conducted in April 2016.	Raytheon ATM system Support AIDC ICD Version 3 from Q4/2016.	
MACAO, CHINA	ATN/AMHS interoperability test with Beijing commenced in March 2009. ATN/AMHS circuit with Hong Kong put into operational use in end Dec. 2009.	COMSOFT	(Not applicable for using AIDC, looking into the possible application (some way) between TWR and ACC/APP).		

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
COOK ISLANDS					
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA	The ATN BIS Router and AMHS planned for in 2011.		With neighboring ACCs to be implemented		
FIJI ISLANDS	ATN BIS Router and AMHS implemented	COMSOFT	AFTN based AIDC implemented between Nadi/ Brisbane, Auckland and Oakland.	- Support and implemented AIDC messaging: ABI, EST, CPL, CDN, ACP, TOC, AOC with all three centers - AIDC ICD version 2.0 implemented with Auckland and Oakland. - AIDC ICD Version 1.0 implemented with Brisbane	
FRANCE ***(French Polynesia Tahiti)***			Implementation of AIDC (based on Version 3) with adjacent centres (Oakland and Auckland) since 2009		
INDIA	Dual stack ATN/lp router and AMHS implemented at Mumbai in 2011	COMSOFT	AIDC planned with Bangladesh, Myanmar, Thailand, Pakistan, Nepal, Seychelles, Malaysia, Indonesia, Sri Lanka, Kenya, Oman and Maldives	1) Raytheon at New Delhi, Mumbai and Chennai 2) Selex at Hyderabad and Bengaluru.	1) Major Indian airports and ATC centres have integrated ATS Automation Systems having AIDC capability. Successful AIDC trials have been carried out

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
			Mauritius and Somalia. Successful AIDC trials done between Chennai-Kuala Lumpur, Chennai-Male, Ahmedabad-Karachi, Delhi-Karachi (One way towards Delhi)	3) INDRA at 39 locations	amongst major ATSUs within India. 2) AIDC implemented between Chennai and Mumbai. 3) AMHS implemented and working between A. BBIS: Mumbai-Singapore, Bangkok B: BIS: Mumbai, Kathmandu, Dhaka
INDONESIA	AMHS trial with Brisbane waiting for direct link BNE – UPG will be finished 3Q2016 ATN BIS Router and AMHS are still ongoing trial (POT) due to upgrade bandwidth with Singapore	ELSA	Implementation Chennai – Jakarta, Ujung Pandang – Jakarta, Melbourne – Jakarta; planned for its implementation in 4Q2018 Singapore – Jakarta; Testing will be conduct as soon as possible after ATM system Jakarta is ready to AIDC messaging in 4Q2018 Brisbane – Ujung Pandang; plan for its implementation with Brisbane in 4Q2016. Manila – Ujung Pandang; - Testing is still on going. - Plan for implementation with Manila 1Q2017.	Thales in Makasar able to support ICD Version 3 since December 2015	With the rest of Jakarta's adjacent ATSUs will be implement in 2019 and beyond. (Colombo, Kuala Lumpur, Kota Kinabalu) Waiting for direct link BNE – UPG will be finished 3Q2016 Between PNG – Ujung Pandang, the implementation are waiting for PNG's ATM

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
			Kota Kinabalu – Ujung Pandang; - Testing is still on going. - Plan for implementation with Kota Kinabalu 2Q2017		system upgraded. Between Oakland – Ujung Pandang is not planned yet, due to traffic volume consideration (very low).
JAPAN	ATN BBIS router and AMHS installed at 2000. Connection tests with USA 2000 - 2004 and put into operational use in 2005. ATN BBIS router (to apply to Dual Stack) and AMHS (to upgrade in 2015. The connection test with each country which is not currently connecting is started after update.	NEC	AIDC implemented between Fukuoka ATMC and Oakland ARTCC in 1998. AIDC implemented between Fukuoka ATMC and Anchorage ARTCC in 2005. AIDC implemented between Tokyo ACC/Fukuoka ACC and Incheon ACC in 2010. Implemented between Fukuoka and Incheon since June 2009. AIDC implemented between Fukuoka ACC/Naha ACC and Taibei ACC implemented . AIDC between Fukuoka		

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
			ACC and Shanghai ACC under negotiation (2014)		
KIRIBATI					
LAO PDR	ATN BIS Router and AMHS completed, planned for operation with Bangkok since 4Q 2016.	THALES	AIDC with Bangkok planned for 2016. Testing with Ha Noi for 2017, with Ho Chi Minh2017, With Cambodia for 2016	THALES which is able support ICD Version 2.	
MALAYSIA	ATN BIS Router completed 2007. AMHS planned for Q42016.	FREQUENTIS	AFTN AIDC planned with Bangkok ACC – Middle 2Q2016. AIDC between Kuching and KK FIR already implemented in 2014 via AFTN. Between Kuala Lumpur and Chennai trial successful scheduled for operation from 1Q2016. Plan for trial with Singapore from Mid. November 1Q 2016.	SELEX which is able to support ICD Version 3.	

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
			Plan for trial with Ho Chi Minh from 1Q 2016 Between Kota Kinabalu and Singapore 4Q2015 Kuching and Singapore for 1Q2016 Kota Kinabalu and Makassar 4Q2015		
MALDIVES	Planned for 2016 as existing AFTN was upgraded recently to make it compatible with protocols of interconnected AMHS systems and the flight plan format 12.		System is AIDC ready. Implementation with ACC's (Chennai, Colombo, Mumbai, Melbourne and Mauritius) plan for 2017.	SELEX which is able to support ICD Version 3.	
MARSHALL ISLANDS					
MICRONESIA (EDERATED STATES OF)					
Chuuk					
Kosrae					
Pohnpei					
Yap					

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
MONGOLIA	AMHS/AFTN gateway implemented 2012. ATNBIS router implemented in 2014. Coordinating with China using ATN/AMHS connection technical trials conducted in 2014.	COMSOFT	ATM automation system supports both AIDC and OLDI. Coordinating with Russia on OLDI connection in target date 2016. Coordinating with China on AIDC connection technical trial in progress. New testing with China in June 2016 after upgrades of ATM system in Beijing and Ulaanbaatar in April 2016.	INDRA Aircon 2100 supporting AIDC ICD Version 2.	
MYANMAR	AMHS including ATFTN/AMHS gateway implemented in Nov. 2011	THALES	Plan for with Bangkok with target for implementation in 2016.	THALES	
NAURU					
NEPAL	BIS Router and AMHS commissioned with Kathmandu Mumbai circuit on 2 June 2014.	COMSOFT	AIDC between Kathmandu and Beijing and KTM-BBN and KTM-CCU planned for 2016		
NEW CALEDONIA	New router and AMHS planned for commissioning Q12017	]COMSOFT			

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
NEW ZEALAND	IP based AMHS connections with USA 2Q2016.	COMSOFT	AIDC implemented between New Zealand, Australia, Fiji, Tahiti, Chile and USA.		
PAKISTAN	ATN/AMHS considered as Phase II implemented since 2010.	COMSOFT	Implemented between Karachi and Lahore ACCs Plan to implement AIDC with Mumbai and Muscat for 2015		Existing Radar system being upgraded.
PAPUA NEW GUINEA	Plans to create a newly duplicated digital communications line connecting with existing and new sites and AMHS system implemented in 4Q2014	COMSOFT	Plan to implement with all neighboring FIRs in 3Q 2016	COMSOFT which is able to support ICD Version 3	
PHILIPPINES	New ATN/AMHS was installed at the New CNS/ATM Center in Manila. Site Acceptance was successfully done on October 2015. Transition from AFTN to AMHS using the new AMHS is planned in the 1st Quarter of 2017. The AMHS Interoperability test with Hong Kong is planned in Q1/2017. For Singapore 1st Quarter 2018. AMHS interoperability test with Oakland USA is planned in the 4rt Quarter of 2017.	COMSOFT	**Technical Trials:** On-going with Singapore, Ujung Pandang and Taipei ACCs; 2Q2016 – Hong Kong ACC; 1Q2017 Oakland ARTCC; 4Q2016 – Ho Chi Minh ACC **Planned Implementation:** 3Q2016 – Singapore ACC; 3Q2017 – Ujung Pandang ACC; 4Q2016 – Taipei ACC; 4Q2017 – Oakland ARTCC; 4Q2017 – Ho Chi Minh ACC	THALES which is able to support ICD Version 2.	

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
REPUBLIC OF KOREA	ATN/AMHS circuit with China put into operational use in June 2011. ATN/AMHS test with Japan to be conducted	SAMSUNG	AFTN based AIDC implemented between ACC and Fukuoka ATMC. AIDC between Incheon and Dalian under testing and planned for operation in the end of 2016		
SINGAPORE	AMHS implemented. ATN/AMHS circuit with India put into operational use in March 2011. ATN/AMHS circuit with UK put into operational use in March 2012. ATN/AMHS circuit with Thailand put into operational use in December 2014. On-going ATN/AMHS trial with Indonesia, Malaysia and Viet Nam. Planned implementation with Australia by 2Q2016.	COMSOFT	Operational with Ho Chi Minh implemented July 2014. Technical trials with Malaysia (Kota Kinabalu, Kuching and Kuala Lumpur ATCCs) on going since Dec. 2014. Further technical testing is planned for April – May 2016. Revised planned operational implementation by Dec. 2016. Technical trials with Manila ACC ongoing since Dec. 2014. Revised planned operational implementation by Sept. 2016.	THALES currently support ICD Version 1 and to be upgraded to Version 3 in December 2016.	

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
			Technical trials with Jakarta ACC will be initiated once the Jakarta ACC ATMS renewal is completed.		
SRI LANKA	ATN BIS Router Planned for 2013. AMHS (Domestic) and AMHS/AFTN Gateway implemented by Oct. 2011. - Mumbai tested Q1/Q2 2015 operational planned for Q4 2016; - Singapore testing in Q4 2016 operational for 2017; - Male testing and operational date TBD.	IDS	Trials with Male' planned for in 2017. Trial with Chennai on-going. Plan for implementation in 3Q2016 and with Melbourne plan for 3Q2015 and implementation for 1Q2017.	INTELCAN which is able to support ICD Version 3.	
THAILAND	BBIS/BIS Routers already implemented. AMHS has been implemented since July 2011. Connection with Cambodia, India, Singapore, Hong Kong, China implemented. Pre-operational test (POT) with Bangladesh, Lao PDR, Malaysia completed, implementation planned for end of 2016. Interoperability Test (IOT) with Myanmar, Beijing, China completed, pre-operational test planned for end of 2016. Interoperability Test; with Italy and Vietnam planned for end of 2016.	AEROTHAI's AMHS System and Ubitech System	Initial Trial with Cambodia and Lao PDR underway. Coordination and initial trial with Malaysia and Myanmar by the end of 2016. Plan for implementation starting from 2017.	THALES which is being implemented with planned completion in Early 2017. AIDC feature supports APAC AIDC ICD V.3.	

State/Organization	ATN G/G Boundary Intermediate System (BIS) Router/AMHS	AMHS Vendors Selected	AIDC	ATM System selected to support AIDC and Associated ICD (Implementation Status of the Basic 5 message set supported)	Remarks
TONGA	AMHS planned for 2008. The provider is linked to the New Zealand AFTN				CPDLC and ADS-C is not considered for lower airspace
UNITED STATES	AMHS implemented. (Salt Lake City & Atlanta). Transition using AMHS when counter parts ready	IN-HOUSE	AFTN based AIDC implemented.	IN-HOUSE which is able to support APAC and NAT ICDs currently Version 2.	
VANUATU					
VIET NAM	AMHS (basic) implemented. Trial phase from Q4/2015 to Q4/2016 IOT with Thailand in progress from Q4/2015 Plan to use AMHS in Q4/2016	IN-HOUSE	Operational with Singapore in April 2014. Trial with Singapore for additional messages sets in 2016. Technical testing with Cambodia already done; Plan for trials with Lao. PDR in 2016 and with Malaysia to be confirmed.	Support ICD Version 1.0 with THALES at Ho Chi Minh ATM system. Support ICD Version 3.0 with Selex at Ha Noi ATM System.	

Common Regional Virtual Private Network (VPN) Operations Group (OG) of Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) (APANPIRG CRV OG)

TERMS OF REFERENCE

1. Background

The establishment of APANPIRG CRV OG was proposed during the deliberations of the CRV Task Force (TF) as a dedicated group to provide oversight of the CRV operations and the performance of the CRV Service Provider. The APANPIRG CRV OG is formally established by APANPIRG Decision XX /XX.

2. Terms of Reference

The Common Regional Virtual Private Network (VPN) Operations Group (OG) will provide oversight of the function and performance of the CRV and the performance of the Service Provider. The following are the activities to be performed:

a) Oversee the implementation of the CRV post Contract Award;

b) Manage issues arising from the transition with CRV TF, if any;

c) Co-ordinate and standardize the establishment or upgrade of CRV services as required;

d) Co-ordinate activities with other ICAO CRV OGs, if any, to make sure that decision making and communication with CRV Service Provider is consistent and timely;

e) Oversee the performance of the CRV Service Provider, including customer service;

f) Oversee the performance of the CRV network;

g) Oversee the escalation and solving by the CRV Service Provider of issues associated with the provision of the CRV, including safety and security related issues;

h) Assist with the resolution of issues associated with the provision of the CRV among the CRV Users as required, including safety and security related issues;

i) Assist with the migration of Aeronautical Fixed Services (AFS) onto the CRV, in line with the GANP and seamless ATM plan;

j) Maintain CRV OG documentation associated with the function, performance and management of the CRV, including the CRV OG Operations Manual, a list of CRV users and a record of variations to the common tender package;

k) Accept deliverables from the CRV Service Provider on behalf of the CRV Users as required;

l) Promote the use of CRV; and

m) Perform any other activity as required by CRV operations.

3. Reporting

The CRV OG will report to Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) through ACSICG and CNS SG.

4. Participation

The CRV OG will include all APAC Member States/Administrations, and any other organization as needed.

5. Conduct of the work

It is anticipated that the CRV OG will conduct its work primarily by Web Conferences, teleconferences and other electronic means of communications. Face to Face meetings of CRV OG may be required on an annual basis.

The ICAO APAC Regional Office will provide secretariat support for the CRV OG.

6. Rapporteur

There will be two Co-Chairpersons of the CRV OG, one primarily responsible for Asia coordination and the other for Pacific coordination.

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A) Revised TOR of ACSICG

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

~~Name and Terms of Reference~~

~~Name: "ATN Implementation Coordination Group (ATNICG)" be replaced by "Aeronautical Communication Services Implementation Co-ordination Group (ACSICG)"~~

~~Terms of Reference (TORs)~~

Complete implementation of Asia and Pacific (APAC) Aeronautical TelecCommunication Network (ATN) and voice/data service to support the evolving ICAO operational requirements for the dynamic exchange and management of aeronautical information. ~~and data.~~

Composition

The Group will be composed of experts nominated by ICAO member States/Administrations in the Asia and Pacific Regions.

Reporting

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

B) Revised TOR of PBNICG

Revised Terms of Reference (TOR)
APAC PBN Implementation Coordination Group (PBNICG)

1) Serve as the primary APAC Regional Body to support PBN implementation, harmonization and prioritization with a goal to enhance safety and efficiency of aircraft trajectories and operations. The forum also takes into account activities related to the implementation of relevant ASBU elements, with initial focus on B0-CDO, B0-FRTO, B0-CCO, and B0-APTA. The following are the main activities envisaged:

a. Monitor PBN implementation by of APAC States/Administrations of PBN related Assembly Resolution and of the Seamless ATM items relating to Optimal trajectories, associated regional priorities and targets, and make recommendations as necessary in areas where ICAO and international organizations can provide assistance.

b. Through ICAO, provide guidance to States to update their PBN implementation plans. Identify challenges within State PBN Implementation Plans and PBN implementation activities and advise States in addressing these challenges in a harmonized manner.

c. Taking a multi-disciplinary approach, promote more efficient flight operations and trajectories and, as necessary, address related topics including Air Traffic Services (ATS) route network.

d. Analyze and report operational benefits of PBN implementation and provide regular PBN implementation updated information to ICAO for inclusion in the air navigation reports and regional performance dashboard.

2) Identify issues/action items which are related to the regional implementation of PBN and related ASBU elements, and where appropriate, communicate with related regional groups.

3) Review regional priorities/targets and relevant regional plans as related to PBN implementation.

4) Identify, propose and facilitate where necessary, appropriate corrective action in the development and implementation of action plans by States to resolve identified deficiencies.

5) Review and update Air navigation deficiencies in the field of PBN (as listed in the APANPIRG database);

4 6) PBNICG will report to CNS/SG. CNS/SG will coordinate with ATM/SG.

Composition

The PBNICG will be composed of multi-disciplinary experts with knowledge of and/or responsibility for PBN implementation nominated by ICAO member States/Administrations in the Asia and Pacific Regions and International Organizations. The PBNICG adopts project management principles as necessary. Secretariat support for the PBNICG will be provided by the ICAO APAC RSO ~~with assistance from the~~ and/or APAC RO and ANB. Representatives of ICAO programmes such as COSCAPs and FPP will be invited to participate as applicable.
The scale of the project is regional.

Note: The PBNICG, while ~~undertaking~~ conducting ~~the~~ its tasks, should take into account ~~of~~ the work being undertaken by relevant ICAO Panels and other study/working groups.

C) Revised TOR of SURICG

**TERMS OF REFERENCE OF
SURVEILLANCE IMPLEMNTATION COORDINTION GROUP (SURICG)**

Consists of objectives and deliverables as follows:

The Objectives of the SURICG are to:

1) *Ensure continuous and coherent development of the Surveillance parts of the Asia/Pacific Regional Air Navigation Plan (APAC e-ANP) in a manner that is harmonized with adjacent regions, consistent with ICAO SARPs, the Global Air Navigation Plan and the Global Aviation Safety Plan;*

2) *Facilitate the implementation of Surveillance systems and services identified in the Aviation System Block Upgrades (ASBU) modules, APAC ANP, and Asia/Pacific Seamless ATM Plan elements using the project management principles where appropriate; and*

3) *Review, identify and address major issues in technical, operational, safety and regulatory aspects to facilitate the implementation or provision of efficient Surveillance services in the Asia and Pacific Regions.*

Deliverables to meet the Objectives:

1) Progress report to be submitted to CNS SG addressing the SURICG deliverables (listed in 2 to 13 below);

2) Surveillance parts of the APAC ANP to be reviewed and aligned with work programme of States and, as necessary, amendment proposals prepared to update the APAC ANP to reflect changes in the operational and global requirements;

3) To review the outcome of the Surveillance Panel, SAS Panel, AN-Conf, APANPIRG and CNS SG related to surveillance, revise and update a tasks list and action items for the SURICG and formulate relevant Working Groups to work on those tasks / action items;

4) To develop regional targets/metrics for planning, implementation, measurement and monitoring of Surveillance systems and services;

5) To review and update the Surveillance Strategy by considering currently available and emerging technologies with respect to concept of operations, relative costing, technical and operational performance and maturity of alternative technology/solutions such as primary radar, secondary radar including Mode-S, ADS-B, Multilateration, ADS-C, multi-static primary radar (MPSR) and existing and emerging technology for detection of UAS including RPAS;

6) To study and identify applicable multilateration applications in the Asia and Pacific Regions considering:

- Concept of use/operation
- Required site and network architecture
- Expected surveillance coverage
- Cost Benefits Analysis
- Recommended separation minimums

7) To study and identify applicable Mode S radar applications in the Asia and Pacific Regions considering:

- Concept of use/operation
- Required site and network architecture
- Expected surveillance coverage
- Cost of system
- Matching functionality required in ATC automation system
- the use of Enhanced MODE S data (DAPS)

8) To develop an implementation plan for ~~near term~~ ADS-B applications in the Asia and Pacific Regions including implementation target dates taking into account:

- available equipment standards
- readiness of airspace users and ATS providers
- identifying sub-regional areas (FIRs) where there is a positive cost/benefit for ~~near-term~~ implementation of ADS-B ~~OUT~~; and
- developing a standardised and systematic task-list approach to ADS-B ~~OUT~~ implementation.

9) To coordinate ADS-B implementation plan and concept of operations with other ICAO regions where ADS-B implementation is going on and with relevant external bodies such as EUROCONTROL, EUROCAE, RTCA and Industry;

10) To encourage research and development, trials and demonstrations in the field of Surveillance and other relevant areas ~~and, as necessary~~;

11) Facilitate sharing of surveillance information and expertise between States through organizing educational seminars and providing guidance materials to educate States and airspace users;

12) To support the ICAO in making specific recommendations, developing guidance materials, aimed at improving the Surveillance services by the use of existing and/or new procedures, facilities and technologies; and

13) Draft Conclusions and Decisions to be formulated relating to matters in the field of Surveillance that come within the scope of the APANPIRG or CNS Sub-group work plan.

[Note: The Implementation Coordination Group, while undertaking the tasks, should take into account of the work being undertaken by SAS, Surveillance Panels with a view to avoid any duplication.

The Implementation Coordination Group will report to CNS Sub-group and CNS Sub-group will coordinate with ATM Sub-group.]

Membership:

All APAC member States/Administrations providing air navigation services in the Asia and Pacific Regions.

The Surveillance Implementation Coordination Group shall normally invite representatives of International Organizations recognized by the ICAO Council and Industry partners as required by the group which representing important civil aviation interests to participate in its work in a consultative capacity.

D) Slightly revised TOR of SEA/BOB ADS-B Implementation Working Group

TERMS OF REFERENCE

SOUTHEAST ASIA AND BAY OF BENGAL SUB-REGIONAL ADS-B IMPLEMENTATION WORKING GROUP

Terms of Reference

APANPIRG18 Conclusion 18/38 agreed to the establishment of a sub-regional ADS-B implementation Working Group in the South-East Asia area (SEA ADS-B WG) by the end 2007 to develop the ***terms of cooperation*** and an ***implementation plan*** for near-term ADS-B applications in the sub-region.

APANPIRG/22 Decision 22/34 agreed to rename the Southeast Asia Sub-regional ADS-B Implementation Working Group to "South East Asia and Bay of Bengal Sub-regional ADS-B Implementation Working Group" and tasked the new Working Group to develop a revised Terms of Cooperation and work programme in the sub-regions.

The outcome of the ADS-B Working Group will report to APANPIRG through the Surveillance Implementation Coordination Group ~~ADS-B Study and Implementation Task Force.~~

The SEA/BOB ADS-B WG shall

(a) Develop **Terms of Co-operation** which will include :

- establishing model documents for possible use by States when :

- Agreeing to share ADS-B data, and DCPC (such as VHF radio voice communication) capability between adjoining States for various ADS-B applications (including a sample letter of agreement); or
- Establishing ADS-B avionics fitment mandates

- identifying optimum coverage for ADS-B ground stations and associated VHF radio voice communication in the sub-regional FIR boundary areas.

(b) Develop an **implementation plan** for near term ADS-B application which will delivery efficient airspace and increased safety on a regional basis that include :

- schedule and priority dates to bring into effect ADS-B based services taking into account;

    - Timing of any equipage mandates.

    - Timing of any ATC automation upgrades to support ADS-B.

    - Timing of commissioning of any ADS-B data and associated VHF radio voice communication facilities.

- consideration of major traffic flows

(c) Coordination for implementation of the plan and identify implementation issues and solutions

Composition: The Group will be composed of experts nominated by States in the Sub-region including: Australia, Bangladesh, Brunei Darussalam, China, Hong Kong China Cambodia, India, Indonesia, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam, IATA and CANSO.

Reporting: The Group will present its report to Surveillance Implementation Coordination Group ~~ADS-B Study and Implementation Task Force~~.

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TERMS OF REFERENCE

SWIM Task Force

Objectives: In order to achieve B1-SWIM and the Seamless ATM Plan objectives, ATM and AIM systems - in compliance with global standards for the conceptualisation and exchange of aeronautical, flight and meteorological information - should be implemented in the high density FIRs and high density international aerodromes by November 2022 (PASL Phase III) and in all FIRs and international aerodromes by November 2025 (PASL Phase IV). To that end, the SWIM Task Force will:

a) Benchmark the various successful implementations of SWIM in States and regions to adopt best practices;
b) Develop and maintain a regional roadmap for SWIM services (ATM, AIM, MET, other), dependencies and enablers;
c) Liaise with relevant regional contributory bodies to refine operational and communications requirements (example: AMHS, CRV, etc.);
d) Complement global SWIM governance with regional procedures as needed and define how it can be implemented in APAC, with a particular focus on version management of concept and exchange models, architecture models, cyber-security, data quality management and maintenance of a trusted environment;
e) Provide guidance and training to APAC member States and APANPIRG contributory bodies involved in SWIM-related work;
f) Develop guidance/requirements for publishers/service providers and subscribers/service consumers;
g) Promote enablement of ATM services as SWIM Application Services (SAS);
h) Define how SWIM Registry/Registries and services will be implemented in the APAC region and what the minimum level of information a service needs to provide to the Registry/Registries;
i) Support APANPIRG WG/TF regarding data exchange models of AIXM, FIXM, and IWXXM and examine if any extension is required for the operational use in APAC;
j) Monitor developments by the IMP and escalate issues as required;
k) Implement the APAC Regional SWIM; and
l) Undertake any other tasks related to SWIM implementation that may arise in the future.

Considering the cross-disciplinary nature of SWIM, the Task Force will ensure proper coordination with relevant regional contributory bodies under APANPIRG.

Composition

The SWIM TF will consist of experts from ATM, AIM, MET and CNS from Asia/Pacific States (ANS Providers), and from 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 through ACSICG.

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CNS SG/20
Appendix E to the Report

Project	Task number	Task	Planned Start	Planned completion	Dependencies
SWIM - Definition phase	1-1	Benchmarking of best practices Benchmarking of various successful implementations of SWIM in the different States and regions	2016	2017	SWIM Task Force created, resources available
	1-2	SWIM Regional roadmap Develop and maintain a regional roadmap for SWIM services (ATM, AIM, MET, other),dependencies and enablers Initial roadmap Further maintenance	2016 2017	2017 2022	SWIM ConOPs and Technical Manual
	1-3	Regional coordination Liaise with relevant regional TF/WG to refine operational and communications requirements (example: AMHS, CRV, etc)	2016	2022	SWIM ConOPs and Technical Manual Guidance on IWXXM
	1-4	SWIM governance Complement global SWIM governance with regional procedures as needed and define how it can be implemented in APAC, with a particular focus on version management of models, cybersecurity and data quality management;	2018	2022	SWIM ConOPs and Technical Manual
	1-5	Regional SWIM Registry and architecture Define how SWIM Registry and services will be implemented in the APAC region	2016	2019	SWIM ConOPs and Technical Manual Overall requirements: Refer 2.5.4 of DOC 10039
	1-6	Regional SWIM models Support APANPIRG WG/TF regarding data exchange models of AIXM, FIXM, and IWXXM and examine if any extension is required for the operational use in APAC;	2016	2017	Global model definitions available
	1-7	Monitoring of panels work Monitor developments by the IMP and escalate issues as required	2016	2022	SWIM ConOPs and Technical Manual
	1-8	Guidance and training - To APANPIRG WG/TF : - Provide guidance to APANPIRG WG/TF using SWIM - To States:- Interregional workshop Develop SWIM implementation guidance for phase 1 Develop SWIM implementation guidance for phase 2 (dual operations) Regional workshops	2016 2017 2016 2019 As needed	2022 2017 2018 2020	SWIM iKit
	1-9	Definition of service models that will help realise the benefits of SWIM			
SWIM Implementation Phase 1 - initial expansion of services and preparation of phase 2	2-1-1	Promote new needs and new services and maintain database of publishers (ID/access points/services/interface/format..) pending registry implementation	2016	2019	
	2-1-2	Implement SWIM registry and architecture	2019	2022	Task 1-5 completed CRV implemented
	2-1-3	Support validation and publication of SWIM based applications	2016	2019	Availability of SWIM applications (task 2-1-2) SWIM registry and architecture (DNS service, security, etc) (task 2-1-4) Procedures/SLA: Task 1-4 Models: 1-6
	2-1-4	Develop guidance/requirements for publishers/consumers;	2017	2018	Task 1-5
SWIM Implementation Phase 2 - generalization	2-2-1	Coordinate SWIM implementation and transition from existing environment to SWIM based on national transition roadmaps	2022	2025	SWIM ConOPs and Technical Manual National transition roadmaps
	2-2-2	Facilitate dual operations to support both legacy service and new service to prevent duplicated messages as well as rejected messages	2022	2025	

REVISED NAVIGATION STRATEGY FOR THE ASIA/PACIFIC REGION

Considering:

a) the material contained in the Performance Based Navigation Manual (Doc 9613) for enroute, approach, landing and departures operations;

b) operators are qualified for PBN operations;

c) GNSS is the primary navigation system for RNP;

d) APV operations may be conducted with either BARO-VNAV or augmented GNSS;

e) Augmented GNSS is available to support Category I, and will be able to support Category II and III operations by 2018;

f) ILS is capable of meeting the majority of requirements for precision approach and landing in the Asia-Pacific Region;

g) ILS CAT III is operational;

h)the need to maintain aircraft and ground interoperability both within the Region and between the Asia/Pacific Region and other ICAO regions and to provide flexibility for future aircraft equipage;

i) single-frequency GNSS may be susceptible to radio frequency interference and ionospheric disturbances and use of multi-frequency, multi-constellation GNSS may mitigate risks caused by narrow band frequency interference and ionospheric disturbances.

j) The region has developed an ionospheric threat model for GBAS

Strategy

i) Convert from traditional terrestrial-based instrument flight procedures to PBN operations in accordance with the Asia/Pacific Seamless ATM Plan;

ii) retain ILS as an ICAO standard system for as long as it is operationally acceptable and economically beneficial;

iii) implement GNSS with augmentation as required for APV and precision approach or RNP operations where it is operationally and economically beneficial;

iv) Implement the regional ionospheric threat model for GBAS as appropriate

v) implement the use of APV operation in accordance with the Asia/Pacific Seamless ATM Plan;

vi) rationalize terrestrial navigation aids, retaining a minimum network of terrestrial aids necessary to maintain safety of aircraft operations;

vii) protect all the Aeronautical Radio Navigation Service (ARNS) frequencies through education, appropriate regulation and the active detection and elimination of intentional and unintentional interference sources.;

viii) ensure civil-military interoperability; and

ix) continue monitoring the development of GNSS elements and alternative position, navigation and timing.

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CNS SG/20

Appendix G to the Report

GBAS safety assessment guidance related to anomalous ionospheric conditions

Draft

06 July 16

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1. Introduction

1.1. GBAS and its fundamental principles

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

GBAS is a navigation system to support aircraft precision approach and landing. SARPs for CAT-I precision approach has been effective since 2001, and ones for CAT-III (GAST-D; GBAS Service Type D) is now under the final validation [2, 3]. GBAS is based on the "local" differential positioning method which subtracts common error components from each GNSS ranging source signals received at a user's onboard system. The GBAS ground subsystem generates differential correction and integrity messages from three or more (usually four) sets of ground GNSS antenna and receivers (see Figure 1). As major error sources, it is well known that there are satellite ephemeris and clock errors, propagation delays due to the ionosphere and troposphere, where the refractivity is more than one. It is important that these remaining errors in each ranging source after the correction are increased in accordance with distance from the GBAS ground subsystem, namely the centroid of the ground GNSS receivers. Multipath effects are also an error factor for GNSS differential technique on both ground and aircraft that do not increase with distance. However, they can be reduced by averaging measurement data of ranging sources among the multiple ground receivers.

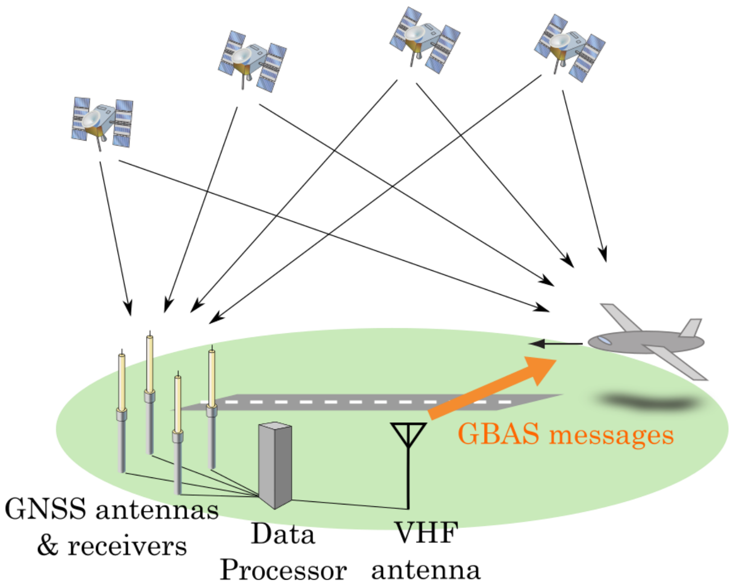

Figure 1. GBAS outline

Because it is necessary for an operational GBAS ground subsystem to meet the extreme safety requirements defined by the SARPs in Annex 10, its validation only by monitoring continuous run behavior is not enough for operational approval. Service provider has to prove the system is enough safety to meet the safety requirements, and each country or regional regulator has to judge whether it satisfies them or not.

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

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

Although a system is safer with consideration of more ionospheric anomalous cases and scenarios, there should be an appropriate safe level enough to meet the targeted requirements. An ionospheric threat model is used to analyze and evaluate impacts of the ionospheric effects on GBAS. The threat model is developed based on ionospheric effects on GBAS considering actual ionospheric characteristics. It also describes threat space for safe GBAS design such as ranges of related parameters to consider. Using the threat model, it is required to evaluate users' remaining integrity risk including simulation analysis. If GBAS could not protect users with a targeted safe level against all possible cases, it is also needed to develop mitigation methods to satisfy the requirements. An integrity monitor to detect and exclude anomalous ranging source affected by ionospheric disturbances is one of such mitigation methods. Because GBAS safety requirements not only integrity but also continuity, required performances of an integrity monitor contain a false alert rate as well as a missed detection rate. Note that decrease in available ranging sources due to satellite exclusion by integrity monitor degrades system availability. Thus, the ionospheric threat model is used for evaluation of impacts, development of mitigation method and validation of the final performances. It is important to develop ionospheric threat model appropriate and enough for safe system design [4].

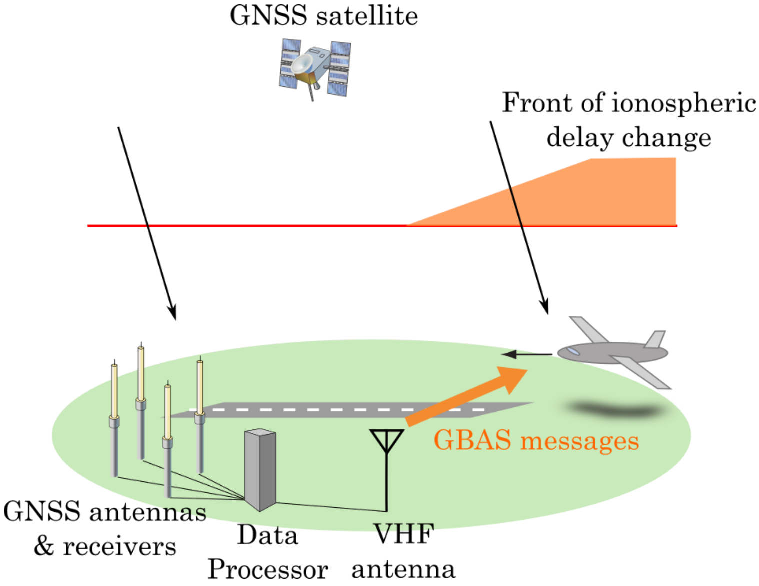

Figure 2. An example scenario of ionospheric delay anomaly for GBAS.

1.3. Ionospheric effects on GBAS

1.3.1. Propagation delay

In GBAS, the application of differential corrections by users almost completely removes ionospheric delay under nominal condition. However, range errors due to ionospheric delay can become significant if there is a large spatial gradient between ground station and user. If this gradient is large enough, it can create a large differential error (e.g., greater than 1 meter) in between the several kilometers separating the ground system and users. This error is increased through "carrier smoothing", where carrier-smoothed pseudorange is calculated using changes in the carrier-phase measurement to reduce the random noise in the code measurement [5]. This process increases ionospheric range error because the ionosphere delays code pseudorange, whereas it advances carrier phase. Because the absolute magnitudes of both effects are almost the same, ionospheric error almost doubles in carrier-smoothed code under steady-state conditions. Also, the "memory" in this filter extends the effective separation between ground station and user by a quantity roughly equal to the distance the user aircraft moves horizontally (toward the ground station) over two smoothing time constants.

1.3.2. Scintillation effects

It is known that active ionosphere often causes scintillation effects which disturbs power and phase of GNSS signals. The strong scintillation sometimes causes loss of lock on GNSS signals from multiple satellites simultaneously. The GBAS is not a countermeasure against scintillation and users should be aware that availability and continuity of navigation may be degraded due to scintillation effects. A useful guidance is: 'Guidance material on scintillation measurements', ISTF/3-WP/9 [6].

2. Ionosphere conditions to consider for GBAS safety analysis

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

GBAS protects users under "nominal" or “typical” ionosphere conditions by differential correction messages and an evaluation parameter for ionospheric error (σ_{iono}), which is derived from the broadcast parameter σ_{vig} (sigma vertical ionospheric gradient). However, it is required to account for anomalous ionosphere conditions in GBAS ground subsystem safety design. Anomalous conditions are those that generate spatial gradients that are larger than 6 times the value of σ_{vig} after converting σ_{vig} from vertical (zenith) to slant gradients (i.e., multiplying by the satellite-elevation-dependent “obliquity factor” given by the RTCA LAAS MOPS, DO-253C [7]). Under anomalous ionospheric conditions, positioning errors larger than the computed protection levels may occur, where these user-computed protection levels indicate upper bounds of user positioning error for lateral and vertical directions derived from evaluation parameters broadcast in GBAS messages [8, 9]. To mitigate this ionospheric threat on GBAS, it is necessary to detect and exclude the affected ranging sources at GBAS ground stations or to adjust the parameters broadcast by GBAS to reflect possible anomalies. Therefore, it is important to evaluate both nominal and anomalous conditions for a safe system design against ionospheric effects.

2.2. Nominal conditions bounded by PL (protection level)

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

2.3. Anomalous conditions and ionospheric disturbances to consider

2.3.1. Storm enhanced density

Storm Enhanced Density (SED) is an extreme ionospheric density enhancement associated with severe magnetic storms. It generally occurs in mid- to high latitude regions, and its occurrence rate is relatively rare [12].

2.3.2. Plasma bubble

Plasma bubble phenomenon is another type of disturbance that can be summarized as a depletion (rather than enhancement) of ionospheric density relative to the surrounding environment. It has a structure spread along the North-South direction and can produce steep ionospheric spatial gradients and scintillation on GNSS signals [13,14]. It frequently occurs after sunset in high solar activity periods. In the Asia Pacific (APAC) region, its frequency of occurrence is most frequent during equinox seasons from March to April and from September to October.

2.3.3. Other

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

2.4. Ionospheric threat model for GBAS safety analysis

The definition of an ionospheric threat model that includes all possible ionospheric anomaly conditions is required for a safe system design. An ideal threat model should satisfy a necessary and sufficient condition for ionospheric effects on GBAS. Note that underestimation of the threat model bounds might expose users to unmitigated (and therefore unsafe) conditions, whereas overestimation of these bounds may degrade system availability. An Ionospheric front is a model with an ionospheric spatial gradient, and is referred to as ionospheric threat model [15].

2.5. Evaluation of requirements and performance, including integrity monitoring

- Integrity risk and continuity risk
- Risk allocation to ionospheric anomaly in system safety design and requirement for integrity monitor performance
- Total evaluation that remaining risk is less than a targeted level in safe system design.

2.6. Ionospheric front model (wedge model) and its important parameters

Definition of ionospheric threat model is required for a safe system design. An ideal threat model should satisfy a necessary and sufficient condition for ionospheric effects on GBAS. Namely, underestimation exposes users to unsafe condition whereas overestimation significantly degrades system availability. Ionospheric front is a model with an ionospheric spatial gradient, is referred as ionospheric threat model and it is discussed in the next section.

2.6.1. Ranging errors induced by ionospheric anomaly

Simulation analysis provides ranging errors induced by ionospheric anomaly using defined wedge model [8].

2.6.2. Positioning errors in the final implementation

Because ground subsystem has to evaluate not only user's ranging source errors but also their final positioning errors, it performs a kind of position domain monitoring in real time called geometry screening in addition to integrity monitors for ranging source anomalies [16,17,18]. Geometry screening is based on "potential" remaining ranging source error using the threat model and it validates various satellite geometry subsets which include impacted satellites. Since GBAS parameters are set against potential error based on threat model, the system availability also depends on threat model. To reduce potential remaining ranging source error, far filed monitor is one of solutions [19].

2.7. Other important descriptions

2.7.1. Locations, dominant season/time, occurrence rate and number of impacted satellites

3. Development and validation of the threat model

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

3.1. Observation stage

In the observation stage, networks of GNSS stations located close together (e.g., within 10 to 50 km) are needed. Each observation is based on the difference in ionospheric delays between two nearby GNSS stations. In the case of dual frequency measurements for estimating ionospheric delay, inter-frequency biases must be corrected before ionospheric delay differences can be calculated.

It is well known that the error component of the estimated gradient increases in short baseline analysis because the gradient is calculated from difference of ionospheric delay divided by the baseline length (separation between stations) [11]. Moreover, where possible, the baseline length should be comparable with or smaller than the spatial scale of disturbances. Because SEDs are related to magnetic storms, data filtering based on indices caused by magnetic storms are useful for extraction of events, meaning identifying the times when large gradients are most likely to occur [15,20]. Plasma bubbles are created by different ionospheric mechanisms. Therefore, such index parameters are not enough to extract events, but local time filtering remains useful because plasma bubbles occur during local nighttime. Solar activity with a period of about 11 years is also an important factor for observation-based approach. To the degree possible, measurements should be taken near to the peak of this cycle (maximum solar activity)and in the several years following it, as the largest gradients are likely to occur during this period.

3.1.1. Tools like LTIAM

It is important to construct database for safety analysis maintaining their compatibility and qualities. This section introduces some tools, for examples, tools in FAA, ENRI and etc.

3.1.2. Time Step method

It is alternative method to station pair analysis especially for regions without dense GNSS networks.

3.1.3. Other

3.2. Simulation approach

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

3.2.1. Three dimensional analysis

Data analysis of SED with satellite signals from low elevation angle, simulation analysis concerning plasma bubble [21].

3.3. Validation

Threat model should cover observational and simulation results with appropriate safety margin.

4. Post-implementation activities

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

4.1. Monitoring of ionospheric activity

- Solar cycle of about 11 years
- Events

4.2. Maintenance of threat model

- New events which are not covered by the current threat model
- Reconsideration of safety margin

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6. Annexes

6.1. CONUS model

6.2. Safety analysis for GBAS prototyping in Osaka

6.3. Other: Refer to results in Germany, Australia and Korea.

INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

SBAS safety assessment guidance related to anomalous ionospheric conditions

Edition 1.0 – July 2016

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Records of amendments

Amendment Number	Date	Amended by	Comments

Table of Contents

Chapter 1 Introduction

1.1 Background

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

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

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

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

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

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

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

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

1.2 Purpose and scope of this document

1.2.1 The purpose of this document is to provide guidance to evaluate ionospheric error in use of the current (single-frequency) SBAS as a part of integrity assessment. States might use information of this document for:

(i) approval of SBAS system implemented by the State itself;

(ii) approval of an SBAS service provider operating from another State; or

(iii) assessment of GNSS SBAS vertical guidance availability.

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

Chapter 2 Overview of GNSS

2.1 Overview of GNSS

2.1.1 As per ICAO Document 9849 (GNSS Manual), the concept of GNSS means the system consisting of core constellations, augmentation systems, and GNSS avionics (user receivers). Core constellation are GPS and GLONASS operated by the United States of America and the Russian Federation, respectively.

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

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

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

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

2.2 Satellite-Based Augmentation System (SBAS)

2.2.1 Currently there are four SBAS systems in operation: US WAAS (Wide Area Augmentation System), Japanese MSAS (MTSAT-based Satellite Augmentation System), European EGNOS (European Geostationary Navigation Overlay Service), and Indian GAGAN (GPS Aided GEO Augmented Navigation). All SBAS systems are continuously broadcasting augmentation information via GEO (geostationary satellite).

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

2.2.3 The SBAS signal is broadcast at the center frequency of 1575.42MHz, same with GPS L1. The onboard avionics receives the SBAS signal via RF antenna and front-end circuit both common with GPS.

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

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

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

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

2.3 Integrity requirements and threats

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

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

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

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

2.3.5 In general, the protection level consists of two essential components: formal and threat terms. The formal term represents the uncertainty of corrections due to measurement noise which can be derived by covariance matrix for estimation. This term also covers nominal errors involved in clock and orbit information in the ephemeris data. The threat term represents the uncertainty due to rare events in non-nominal conditions.
This term is regard to faulty and anomalous events perhaps not observed yet.

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

Chapter 3 Threat Mitigation Strategy Against Anomalous Ionospheric Conditions

3.1 High level principles

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

3.1.2 The smaller the threat space, the better the performance. The protection levels are computed inside user receivers based on the parameters broadcast from the augmentation system. The broadcast integrity parameters provide information about uncertainty of corrections and are derived from two components: nominal uncertainty and margin for anomalous irregularity, i.e., the threat space. The former is associated with the Normal distribution and is not so large, while the latter is a countermeasure against very rare events and constitutes the dominant component of the protection levels. Large threat space (inside SBAS ground facility) yields large protection levels (inside user equipment), thus degrades availability and continuity of the system. As a result it is possible to improve performance of the system (availability and continuity) by employing a smaller threat space.

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

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

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

3.2 Ionospheric correction by SBAS

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

3.2.2 There are some methods for generation of ionospheric correction information inside SBAS. As an example, the algorithm of WAAS/MSAS, so-called ‘planar fit’, is explained in Appendix A.1.

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

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

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

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

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

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

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

3.3 Necessity of the threat model

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

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

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

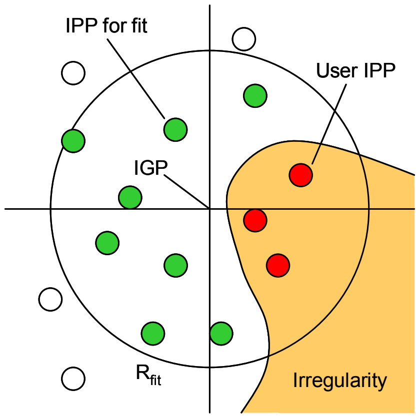


Figure 3-1: Schematic Diagram of Spatial Threat

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

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

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

(1) Mainly, the problem is spatial threats. The threat means local ionospheric irregularities observed by some users, but NOT observed by ground stations. Temporal threats may also be a problem, but we should be able to mitigate this kind of threat with enough archived data.

(2) In general, ionospheric error roughly relates to vertical position error. In approach modes with vertical guidance, an incomplete ionospheric threat model may cause a safety hazard.

(3) Integrity events of operational systems: so far, no integrity events due to ionosphere have been reported by operational SBAS systems. One can check integrity, e.g., if GIVE always overbounds the actual ionospheric error everywhere, using 'Triangle Charts' constructed for this purpose. If integrity is not met, one can increase the magnitude of the threat model. A larger threat model provides more safety margin but results in less availability.

(4) A concern may be 'Plasma Bubble' because, for example, the ionosphere model for some SBAS systems does not explicitly include information about plasma bubbles. It can be interpreted that the effects of plasma bubble events are implicitly bounded by the safety margin embedded in the ionospheric threat model, which might not be the case.

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

(1) Observability of ionosphere: The mitigation strategy is influenced (or constrained) by:
- The number and distribution of ground stations
- The number of signal sources and the number of core constellations in use
- The spatially dense observation of the ionosphere, which reduces the spatial threat by improving ionospheric observability
- The availability of additional ground stations for generation of the threat model since the threat model might be refined if a larger network is available.

(2) Relevance of the ionosphere model used for correction
- An accurate ionosphere model (with enough observations) reduces the threat.
- Geometry of the ionosphere model: Is the planar ionosphere model adequate for equatorial regions? What model could better represent equatorial anomalies?

(3) Archive data available for creation of threat model
- Basically, the threat model is created from the residuals of corrections (meaning the difference between the projected ionospheric delay as corrected by SBAS and the actual ionospheric delay observed separately) with regard to given algorithms and parameters for generation of SBAS ionosphere messages. To compute the residual of corrections, a separate archive of ionospheric delay data for a certain period, ideally a whole solar cycle, is necessary.
- The quality of the threat model depends upon the period and region of the archive data used. More data makes the threat model more accurate.
- While a general rule is difficult to establish, following examples of criteria can be useful.
    - ➢ The archive data should be long enough to cover at least one solar maximum period (meaning the peak of the 11-year solar cycle and several years on either side of the peak).
    - ➢ In the USA, data were collected from all GPS satellites on a continuous basis from a network of stations similar to the WAAS reference network.
    - ➢ In Japan, the threat model was established based on observations at 6 MSAS ground stations for some years, including the solar maximum in 2001. The observations

contain storm days with a Kp index greater than 6 as well as nominal days.

- There are some options in the number and density of stations used to generate the threat model.
  - A network of stations same or similar to the SBAS ground stations.
  - A network of stations greater than the SBAS ground stations. Dense network is useful to make the threat model accurate and reduce margins.

(4) Implementation issues

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

3.4 Creation of the threat model

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

(i) Prepare enough archive data for a certain period for the intended region with dual frequency observations;

(ii) Sort out periods of data that are expected to contain anomalous behavior based on indices of ionospheric and/or geomagnetic behavior, such as Kp and Dst. For example, data in which the worst daily values of Kp w□□□□□□□□ter than 6 and Dst were less than □200 were selected as potentially anomalous in analyzing CONUS data for development of the GBAS threat model [8]. Since SBAS is more sensitive to anomalous ionospheric conditions than is GBAS, somewhat lower thresholds (e.g., worst daily Kp □ 5 and Dst □ □100) might be used for SBAS;

(iii) Compute ionospheric delay measurements by removal of frequency-dependent biases;

(iv) Generate SBAS ionospheric correction and GIVE values, in the form of Message Type 26, based on the SBAS MCS algorithm and parameters;

(v) For the location of each ionospheric delay measurement, compute SBAS correction values based on the contents of Message Type 26 generated during this process;

(vi) The difference between measurement and SBAS correction shows the actual error observed (For example, see Figure 3-2); and

(vii) Accumulate the actual error and take the largest error as the threat - This accumulation might be performed with regard to the appropriate parameters used for generation of ionospheric corrections (Message Type 26), which means that the threat is modeled as a function of the parameters.

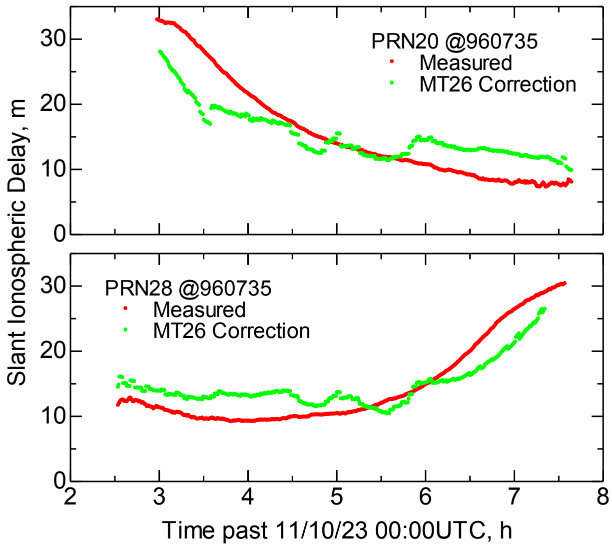


Figure 3-2: Example of Difference between Measurement and Correction

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

Chapter 4 Approval of SBAS

4.1 Approval: availability assessment

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

(i) approval of SBAS system implemented by the State itself;

(ii) approval of an SBAS service provider operating from another State; or

(iii) assessment of GNSS SBAS vertical guidance availability.

4.1.2 The ANSP willing to enable the SBAS service within its FIR is responsible for construction of the safety case describing the system is safe for users against the certification by the regulator. The safety case should contain the explanation of the system architecture, conditions unsafe for users, the potential threats and mitigation including ionosphere.

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

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

4.1.5 Safety index. A tool to measure how much the integrity requirements are met, or how much the safety margin is expected for the intended operation, is so-called ‘safety index’. The safety index is defined as the ratio of the actual user position error to the associated alert limit. As an example, with sufficient margin to establish the integrity level of 1E-07, roughly speaking, the safety index could be less than 5% in the nominal conditions while it could increase up to 10% or 20% even in the non-nominal conditions, both for the LPV operations.

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

4.2 Evaluation of ionospheric conditions

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

4.2.2 For this approval, the appropriate authority shall evaluate:

(i) if the design of the algorithm of ionospheric correction and the ionospheric threat model is appropriate for the intended region;

(ii) the characteristics of the ionospheric threat model using the real data.

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

4.3 Post-adoption activities

4.3.1 As explained at Section 3.1.4, the threat model once evaluated and confirmed does not assure to overbound the anomalous ionospheric delays for the future. Therefore the ionosphere monitoring shall be performed on the regular basis after adoption of the SBAS.

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

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

Appendix A Ionosphere Algorithms for WAAS/MSAS

A.1 Standard planar fit

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

A.1.2 Using the thin shell ionosphere model, the vertical ionospheric delay around an IGP is modeled as:

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

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

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

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

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

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

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

$$\sigma^2_{\hat{I}_v}(\Delta\lambda, \Delta\phi) = \begin{bmatrix} 1 \\ \Delta\lambda \\ \Delta\phi \end{bmatrix}^{\mathrm{T}} \cdot \left[\left(G^{\mathrm{T}} \cdot W \cdot G\right)^{-1}\right] \cdot \begin{bmatrix} 1 \\ \Delta\lambda \\ \Delta\phi \end{bmatrix}. \tag{A-3}$$

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

$$\sigma^2_{IGP_k} = \max\begin{pmatrix} \sigma^2_{\hat{I}_v}(2.5, 2.5), & \sigma^2_{\hat{I}_v}(-2.5, 2.5) \\ \sigma^2_{\hat{I}_v}(2.5, -2.5), & \sigma^2_{\hat{I}_v}(-2.5, -2.5) \end{pmatrix}. \tag{A-4}$$

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

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

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

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

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

$$R_{irreg} = \sqrt{\frac{\chi_{1-P_{FA}}^2(n-3)}{\chi_{P_{MD}}^2(n-3)}}. \tag{A-6}$$

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

A.2 Ionosphere Estimation Algorithm Based on Kriging

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

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

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

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

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

IGP. The weight vector **w** is determined as

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

$$\mathbf{s} = \begin{bmatrix} 1 & \Delta\lambda & \Delta\phi \end{bmatrix} \qquad \text{(A-9)}$$

where G is an $N \times 3$ design matrix which describes the geometry of IPPs, and W^{-1} is the covariance matrix of the observation set, $\mathbf{I}_{v,\mathbf{IPP}}$. $\Delta\lambda$ and $\Delta\phi$ are relative longitude and latitude from the location of the IGP, respectively.

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

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

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

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

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

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

A.3 Spatial threat model

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

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

A.3.3 In order to account this type of threat, WAAS and MSAS employ the ionospheric spatial threat model. The term $\sigma^2_{undersampled}$ in Eqn. (A-5) is determined by the threat model so that it ensures the actual ionospheric error is always overbounded by the threat model for any users in the service volume.

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

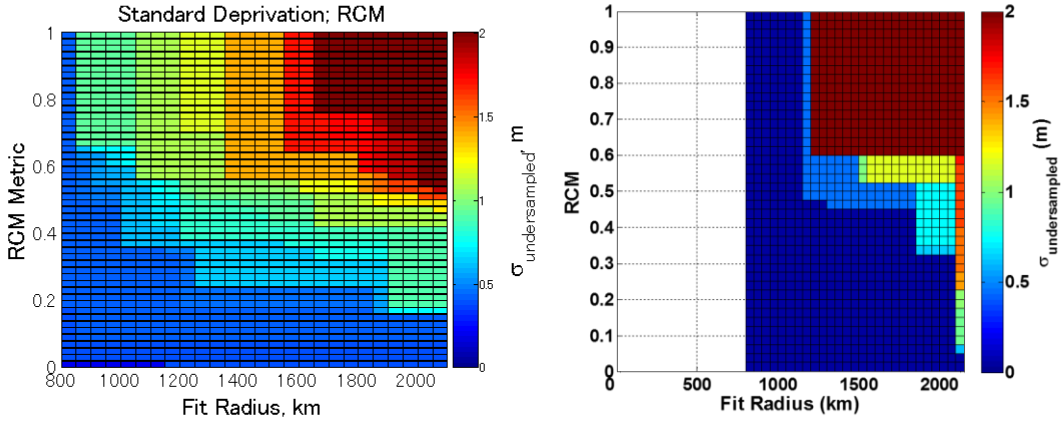
$$\begin{bmatrix} 1 \\ d_{cent,x} \\ d_{cent,y} \end{bmatrix} = \frac{G^{\mathrm{T}} \cdot W \cdot \mathbf{1}}{\mathbf{1}^{\mathrm{T}} \cdot W \cdot \mathbf{1}} \qquad \text{(A-7)}$$

$$RCM = \sqrt{d^2_{cent,x} + d^2_{cent,y}} \Big/ R_{fit}$$

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

$$G_i = \begin{bmatrix} 1 & \mathbf{d}_{IPPi} \cdot \mathbf{e}_E & \mathbf{d}_{IPPi} \cdot \mathbf{e}_N \end{bmatrix}, \qquad \text{(A-8)}$$

where $\mathbf{d}_{IPPi}$ is a vector to i-th IPP from the IGP, and $\mathbf{e}_E$ and $\mathbf{e}_N$ are unit vectors directing east and north from the IGP, respectively. The matrix W in Eqn. (A-7) is weighting matrix same to Eqn. (A-2). $\mathbf{d}_{cent} = \begin{bmatrix} d_{cent,x} & d_{cent,y} \end{bmatrix}^{\mathrm{T}}$ is the weighted centroid of IPPs for fit.



(a) Spatial Threat Model for MSAS (b) Spatial Threat Model for KASS

Figure A-1: Example of Spatial Threat Model

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

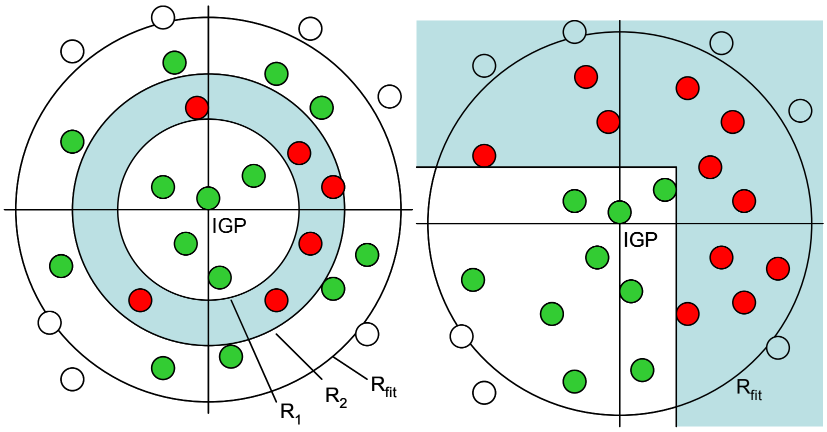
A.3.6 An example of the ionospheric irregularity threat model for Korea Augmentation Satellite System (KASS) is shown in Figure A-1 (b). This model is an example which is developed using ionospheric storm data collected from reference stations in South Korea [11].

A.4 Generation of spatial threat model

A.4.1 The current threat model for MSAS was created by the data deprivation scheme [4]. In this scheme, the set of IPPs observed at an epoch is divided into two sets, the set of measurements used for the fit and the set of virtual users. The planar fit algorithm is performed on the first set of measurements, and ionospheric delays at IPPs of the virtual user set are estimated from the second. Each residual between the planar fit estimate and a virtual user measurement provides a sample of possible error to which users are exposed.

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

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



(a) Annular Deprivation (b) Three-Quadrant Deprivation

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

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

A.4.5 In addition to these two deprivation schemes, here called 'standard deprivation,' used to create the current MSAS threat model, the malicious deprivation scheme has been developed [7]. This scheme provides the worst case undersampling condition with a lesser number of IPP removals. If the storm detector trips, the IPP with the largest residual from the plane is removed and set to be used as a virtual measurement, then planar fit is performed again. If storm detector trips again, the same process is repeated. The number of removed IPPs removed by this method is limited to no more than two for our study.

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

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

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

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CNS SG/20
Appendix I to the Report

Guidance Material on collection of Ionospheric Scintillation data at strategic locations in the Low-latitude Region

(Ver. 1.2)

1. Background

The second meeting of Ionospheric Studies Task Force (ISTF/2) noted the limited scintillation monitoring facilities established in the region, and decided to develop a guidance material on collection of scintillation data at strategic locations (Action Item 1). This document has been developed to address the AI-1 of ISTF/2.

There are two types of ionospheric scintillations in GPS measurements, amplitude and phase scintillations. Amplitude scintillation refers to rapid fluctuation in signal intensity (or carrier-to-noise ratio, C/N0) measured by a receiver, while phase scintillation refers to rapid fluctuation in the carrier-phase measurements. Levels of amplitude and phase scintillations are commonly represented by the standard deviations of amplitude and phase, respectively S4 and σ_φ, in a certain time period (typically 1 min). The ways of estimating the S4 and σ_φ indices are given in Appendices A.1 and A.2.

For the amplitude scintillation, rapid sampling of C/N0 is necessary, while rapid carrier-phase measurements are required for the phase scintillation. Furthermore, GPS receivers for phase scintillation measurements need to be equipped with a highly stable clock (oscillator) such as OCXO (oven-controlled crystal oscillator) to distinguish the phase fluctuations due to ionospheric scintillation and clock (oscillator) noise.

Both types of ionospheric scintillations are caused by plasma irregularities in the ionosphere. In the low-latitude regions where the background electron density is high and plasma drift velocity is relatively slow, the amplitude scintillation is dominant. In this guidance, therefore, the amplitude scintillation is focused on.

2. Receiver performance

2.1 Receiving frequency

Since only the GPS L1 (1.57542 GHz) is currently used, GPS L1 single-frequency receivers satisfying other performance requirements in this section are acceptable. In addition to GPS, however, receivers should be capable of GLONASS and SBAS GEO satellites for wide coverage of the sky.

For the use of the L5 frequency in the future, receivers capable of tracking L1 and L5 signals would be a good choice.

If a receiver could track L2 frequency, it could be used to measure ionospheric delays (or ionospheric total electron contents (TECs)).

2.2 Receiver clock

Since the amplitude scintillation is of interest, a highly stable clock is not necessary, but a standard clock such as TCXO (temperature compensated crystal oscillator) is enough.

2.3 Sampling rate

The amplitude scintillation is caused by the Fresnel diffraction due to the ionospheric irregularities. The typical scale size causing the Fresnel diffraction (D_F) is described as

$$D_F = \sqrt{2\lambda h} \tag{1}$$

where λ is the wavelength of the radio wave (0.19 m for the GPS L1 frequency) and h the height of the irregularities (typically 300-400 km). Thus, the typical scale size is 300-400 m. The amplitude will fluctuate at the Fresnel frequency

$$f_F = V / D_F \tag{2}$$

where V is the drift velocity of the irregularities. Since the drift velocity of plasma irregularities (V) is typically 100-200 m/s, the amplitude will fluctuate at 0.25-0.67 Hz.

According to the sampling theory, the sampling rate of the amplitude should be at least twice as fast as the Fresnel frequency, 0.5-1.33 Hz. Considering that the spectrum of amplitude fluctuation contains higher frequency components, the sampling rate should be much higher than the Fresnel frequency. It is common to sample the amplitude at 20 Hz or more. It should also be noted that the default sampling rate of the amplitude by the widely used GSV4004B receiver is 50 Hz.

The raw amplitude measurements at high sampling rates can be recorded. However, it would take a lot of file size. Therefore, the raw amplitude measurements could be discarded after calculating and recording scintillation intensity, although the raw amplitude measurements data would still be useful for future re-analysis and irregularity drift measurements with closely spaced scintillation receivers.

If the ionospheric delay is desired to be derived, both the pseudo-range and carrier-phase need to be sampled. However, the sampling rates of them do not have to be the same as the amplitudes, but can be much slower than that of the amplitude. The typical sampling rate for the ionospheric delay measurements is 1 sec. (For GBAS, the minimum sampling rate of a ground subsystem is 2 Hz, though)

TEC measurements can also be used to derive another index of ionospheric irregularities: the rate of TEC Index (ROTI). ROTI is defined as the standard deviation of rate of TEC in a certain time period, typically 5 min [2]. ROTI is another indicator of ionospheric irregularities that can be derived from standard low sampling rate dual-frequency receiver measurements. The way of estimating ROTI is given in Appendix A.3.

2.4 Multi-path effect avoidance

The measured amplitude often fluctuates at low elevation angles due to multi-path effects and result in artificial enhancements in the scintillation level. There are two ways to eliminate the multi-path effects. One is simply to set a higher elevation mask such as 30º. However, it would have a drawback of loosing data at low elevation angles where the path length in the ionosphere is long and more scintillation is expected.

Alternatively, the standard deviation of the code-carrier divergence (sigma-CCD) can be utilized. The code-carrier divergence is the difference between the rates of change in pseudo-range and carrier-phase measurements. When there is no multi-path and ionospheric effects, the rates of change in pseudo-range and carrier-phase changes will be the same, except for ambient and receiver internal noises.

The multi-path signal generally accompanies much larger sigma-CCD than ionospheric scintillation signal, which can be used to distinguish between scintillation enhancements by multi-path and ionospheric irregularities [1]. If a sigma-CCD value calculated for the same period as the S4 index exceeds a certain limit, the signal is likely to be affected by multi-path effects. To do this, the pseudo-range and carrier-phase need to be sampled at a certain rate, such as 1 Hz. Sigma-CCD can be calculated afterwards if the pseudo-range and carrier-phase are recorded, while some receivers such as GSV4004B can calculate sigma-CCD internally and record it. The way of deriving the sigma-CCD is given in Appendix A.4.

2.5 Other useful measurements

The satellite azimuth and elevation angles are not essential, but will make post-analysis easier. The sampling rates of the azimuth and elevation angles can be as low as those of the pseudo-range and carrier-phase.

2.6 Summary

The receiver should be able to track at least GPS L1 frequency signals. Tracking capability of GLONASS and SBAS GEO satellites are very useful.

The receiver do not have to be equipped with a highly stable clock (oscillator) as long as it is used for the amplitude scintillation measurements, which is the case in the low latitude regions.

The most important value to be recorded for the low latitude ionospheric scintillation is the amplitudes (C/N0) of the signal for each satellite. The sampling rate should be much higher than the Fresnel frequency and typically 20 Hz or more. Once the scintillation intensity is calculated and recorded, the raw amplitude measurements data can be discarded, unless future re-analysis or irregularity drift velocity measurements are not planned.

The pseudo-range and carrier-phase can be recorded at relatively low rates than the amplitude, such as 1 Hz. They are not mandatory, but useful to distinguish between ionospheric scintillation and multi-path signals.

The satellite azimuth and elevation angles are not essential, but will make post-analysis easier, if recorded together.

3. Antenna

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3.1 Antenna frequency

Antenna should be able to track signals corresponding to the signals which are desired to be tracked by the receiver.

As described in 2.1, an antenna capable of tracking L1 and L5 signals is a good choice.

3.2 Antenna type

To avoid the multi-path effect as much as possible, a choke-ring antenna or others with equivalent multi-path-resistant performance are preferable. Simple antennas could be used, but with a drawback of lower data availability especially at low elevation angles.

3.3 Antenna environment

Antennas should be located at places with the open sky without obstacles that may shadow satellites down to the elevation angle as low as possible.

The antenna site should be free from obstacles as wide as possible to avoid multi-path effects. Practically, it is very difficult to find ideal antenna locations. Therefore, the sigma-CCD filtering is very useful to enhance data availability under the multi-path conditions.

For example, installation of receiver in localizer building is recommended owing to its strategic location which is usually free from multipath. However, seaside runways are at disadvantage. We have observed more multipath effects in scintillation at sites surrounded by ocean.

3.4 Antenna separation

When more than one scintillation receivers are available, one can consider operating them with spaced antenna groups. There are some advantages of spaced antenna measurements.

With a few 100 m to a few kilometers antenna separation and the high frequency C/N0 data recording, drift velocity of ionospheric irregularities causing scintillation can be derived from the time lag between the two C/N0 variation patterns. It could potentially used to predict propagation of the ionospheric irregularities.

Spaced antenna measurements with separation of several tens to a hundred kilometers, which is comparable to the typical scale size of plasma bubbles contribute to increase the number of points probed by the GNSS signals to achieve spatially denser observations.

Multiple receiver measurements at multiple locations that share common sky () would be useful for redundant measurements against receiver failure. The radius of the area of the ionosphere that can be probed at an altitude of 350 km is about 560 and 1600 km for elevation mask angles of 30 and 5º, respectively.

4. Cables

A cable between an antenna and a receiver should be selected so that the signal level at the front-end of the receiver is in the range suitable for each receiver.

The expected signal level at the front-end of the receiver (P_{in}) is given by

$$P_{in} = P_{nom} + G_{ant} + G_{pa} + L_{cable} + G_{ila} \qquad (3)$$

where P_{nom} is the nominal signal level at the antenna, G_{ant} the antenna gain, G_{pa} the gain of the preamplifier, L_{cable} the cable loss, and G_{ila} the gain of an in-line amplifier. The nominal signal level of GPS on the ground is between -153 and -160 dBm for L1 C/A signal [3]. G_{ant} and G_{pa} depends on the antenna model. L_{cable} is determined by the type, thickness of the cable and proportional to the length.

Cable length should be determined so that P_{in} is in the range of signal level suitable for the receiver. When the cable has to be too long to keep P_{in} in the suitable range, an in-line amplifier can be inserted between the antenna and the receiver. However, the gain should not be too high not to exceed the upper limit of the input signal level.

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Appendix A. Parameter estimation

A.1 Amplitude scintillation index (S4 index)

The amplitude scintillation index (S4 index) is defined as a normalized standard deviation of C/N0 as given by:

$$S4 = \sqrt{\frac{\langle s_i^2 \rangle - \langle s_i \rangle^2}{\langle s_i \rangle^2}} \qquad (4)$$

where < > denotes average , and s_i is the C/N0 in linear scale (not in dBHz) of the i-th satellite. The linear-scale C/N0 (s_i) is related to the C/N0 in dBHz (c_i) as:

$$s_i = 10^{(0.1 \times C_i)} \qquad (5)$$

The period of taking average depends on the time scale of interest. It is common to calculate S4 every 1 min (i.e., the averaging period of 1 min).

A.2 Phase scintillation index (σ_φ)

The phase scintillation index (σ_φ) is basically a standard deviation of carrier-phase measurements. However, the carrier-phase measurements have a trend associated with the change of the geometric range. Therefore, the carrier-phase measurements have to be detrended first.

Defining φ' as the detrended carrier-phase measurements, σ_φ can be defined as:

$$\sigma_\varphi = \sqrt{\langle \varphi'^2 \rangle - \langle \varphi' \rangle^2} \qquad (6)$$

A.3 Rate of TEC index (ROTI)

ROTI is defined for each satellite as the standard deviation of rate of TEC (ROT) as given by:

$$ROTI_i = \langle ROT_i^2 \rangle - \langle ROT_i \rangle^2 \qquad (7)$$

where ROT_i is the rate of TEC of the i-th satellite in the unit of TEC/min as given by:

$$ROT_i(t) = \left(TEC_i(t) - TEC_i(t-\tau)\right)/\tau \qquad (8)$$

where τ is the sampling interval.

A.4 Sigma-CCD

Sigma-CCD is defined for each satellite as the standard deviation of code-carrier divergence as given by:

$$SigmaCCD_i = \langle d_i^2 \rangle - \langle d_i \rangle^2 \qquad (9)$$

where d_i is the code-carrier divergence of the i-th satellite as given by:

$$d_i = \left(\rho_i(t+\tau) - \rho_i(t)\right) - \left(\varphi_i(t+\tau) - \varphi_i(t)\right) \qquad (10)$$

where $\rho_i(t)$ and $\varphi_i(t)$ are respectively the pseudo-range and carrier-phase measurements of the i-th satellite at a time t, and τ is the sampling interval of the pseudo-range and carrier-phase.

The period of taking average should be the same as S4 index, and typically 1 min. The sampling interval of the pseudo-range and carrier-phase is typically 1 sec.

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LIST OF CONTRIBUTORS TO THE TECHNICAL ARTICLE ON GBAS IONOSPHERIC MODEL

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Acknowledgments: Data sources from the following Organizations, by alphabetical order:

- Asia-Pacific Economic Cooperation, GNSS Implementation Team;
- Australia;
- Hong Kong China;
- India;
- Indonesia, National Institute of Aeronautics and Space in Indonesia;
- Philippines, National Mapping and Resource Information Authority (NAMRIA);
- Singapore; and
- Thailand

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International Civil Aviation Organization

METP-WG/MISD/2-SN/xxxx
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STUDY NOTE

MEETING OF THE METEOROLOGY PANEL (METP) METEOROLOGICAL INFORMATION AND SERVICE DEVELOPMENT WORKING GROUP (WG-MISD)

SECOND MEETING

Montreal, Canada, 11 to 13 July 2016

Agenda Item 5: Matters Relating to WG-MISD Space Weather Work Stream
5.1: Review and Discuss Space Weather Work Stream Deliverables

POTENTIAL OPERATIONAL IMPROVEMENTS THROUGH SPACE WEATHER SERVICES TO HELP MITIGATE THE EFFECTS OF SPACE WEATHER ON THE REGIONAL CNS SYSTEMS AND OPERATIONS

(Presented by Japan and Australia)

SUMMARY

This paper presents the report discussed by the Ionospheric Study Task Force established under APANPIRG in Asia-Pacific about high level operational improvements that might be delivered by Space Weather services to mitigate the effects of space weather on the CNS systems and operations.

1. INTRODUCTION

1.1 The Ionospheric Study Task Force was established in 2011 by APANPIRG in Asia-Pacific and met in 2012 for the first time. Its work is now almost completed. Its terms of reference are as follows:

1. *Take the responsibility for identification of the available GNSS data source*

2. *Make recommendation on sharing scenario for Ionospheric data collected*

3. *Make recommendations on selecting ionospheric data sources and sharing scenario for the collected data*

4. *Steer process for evaluation of the data analysis*

5. *Study the need for development of Regional Ionospheric Threat Models for GBAS and SBAS*

6. *Development of Regional Ionospheric Threat Models for GBAS and SBAS if the need is identified*

7. *Establish rules for use of shared data and the result of study for non-commercial purpose*

8. *Investigate the effects of space weather on CNS systems in the APAC Region.*

1.2 In response to the 8th term of reference of ISTF (Ionospheric Study Task Force) to "investigate the effects of space weather on CNS systems in the APAC Region", a document describing the high level operational needs for Space Weather information to help mitigate the effects of space weather on regional CNS systems and operations has been developed.

1.3 In its first version, it is a short document describing what space weather information is needed by CNS systems in the APAC region. The information could be provided in the future by designated space weather service providers.

1.4 The development of provisions for information on space weather to international air navigation is being addressed by the METP. In the future, if some or all of the proposed services become SARPS, regional planning and implementation of required space weather services will be supported by APANPIRG, specifically through the MET/SG, CNS/SG and ATM/SG.

2. DISCUSSION

2.1 After discussion during ISTF webconference #7 held on 24 September, 2015, it was agreed that a two-step approach to the formulation of space weather impacts on CNS systems should be taken:

- The first step is to identify operational needs irrespective of their feasibility, as this feasibility should be addressed through the work of the METP/WG-MISD.

- The second step is to examine their feasibility and whether the corresponding space weather solutions are global (and should be considered for inclusion at the global level accordingly) or regional only.

2.2 The document includes ten operational improvements in the areas of communications, navigation and surveillance that, if deemed relevant, could become requirements.

2.3 Space weather information as specified in the document would not need to be presented to the airline operator, air navigation service provider, and flight crew memberson a continuing basis. The principle followed is that concerned operators would be warned or alerted when the predicted impact is very likely to affect the services delivered by the operators themselves.

2.4 Therefore it is envisaged that an advisory message would be issued by the relevant space weather centre(s) for the events specified in the document when they affect, or expect to affect, international air navigation within the next six hours. Such advisory message would be sent it is necessary to warn or alert operators (action b/ or c/ described in the operational improvements).

2.5 However some limitations are recognized by the ISTF:

- extensive review by a representative set of airline operators, air navigation service providers, and flight crew members along with the collection examples/occurrences of the described phenomena while characterizing their severity and frequency (from AIG reports, ATS incident reports, operational experience, etc) would help to mature the operational improvements; this could not be done by the Task Force.
- the wording of operational improvements may gain to be more specific;
- the feasibility may have to be further analyzed; however, it was trusted that the SWIM concept and potentialities offered to cross ATM, CNS and MET data in a relatively close future would enable soon these operational improvements.

2.6 Based on the above the METP-WG/MISD Space Weather Work Stream may consider some of the improvements as good candidates for Near Real-Time Space Weather Condition Requirements, and some others for the longer term.

3. ACTION BY THE METP-WG/MISD SPACE WEATHER WORK STREAM

3.1 The METP-WG/MISD Space Weather Work Stream is invited to note the information in this paper.

a) note the information contained in this paper;

b) discuss the requirements identified; and

c) discuss the way forward and any relevant matters as appropriate.

OPERATIONAL NEEDS OF SPACE WEATHER SERVICES
FOR CNS SYSTEMS
(Version 4 – 20 January 2016)

1. Introduction

Space weather can be defined as the conditions on the sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health of aviation flight crews and passengers [1]. This should be consistent with relevant discussion/outcomes on the definition for space weather from the METP/WG-MISD.

A Space Weather Concept of Operations [2] is being revised by the WG-MISD for endorsement by the METP.
In response to the **terms of reference of ISTF to "investigate the effects of space weather on CNS systems in the APAC Region",** this paper summarizes the operational requirements for space weather information in support of CNS systems as foreseen in the APAC region. They could constitute a good input to the discussions of the METP/WG-MISD.

This paper focuses on the operational benefits which could be reaped from space weather information services. Therefore, what is expected from space weather services may not be feasible at the current stage of space weather knowledge.

For those operational improvements whose benefit would be confirmed on a global scale, appropriate coordination with the METP will be undertaken for potential incorporation into the Concept of Operations for International Space Weather Information in Support of Aviation [2].

2. Operational improvements for space weather services

2.1 Communications

Effect: Space Weather phenomena can affect propagation of radio waves used for aeronautical communications. Following COM systems may be influenced:

[i] HF communications may be disturbed by solar X-ray flare. Increased solar X-ray enhances the ionospheric density in the D-region to absorb HF radio waves (Dellinger phenomenon), and long-distance HF communications may be disrupted.

Examples/occurrences with their severity and frequency: to be developed (from AIG reports, ATS incident reports, operational experience, etc)

Operational improvement SW-COM-1:
a) Monitor the predicted impact of HF propagation conditions on high frequency aeronautical mobile communications (controller / pilot) over the next 24 hours in volumes of airspace (ATS) and along trajectories of the subscribed users (ATS units and airspace users) b) Warn concerned users when the predicted impact is very likely to affect the communications such that the Mean opinion score (MOS) equals 3 (fair quality) and publish the description of affected volume of airspace (ATS) and trajectories c) Alert concerned users when the predicted impact is very likely to affect the communications such that the MOS equals 2 or less (poor or bad) and publish the

description of affected volume of airspace (ATS) and trajectories	
☒Global ☒APAC	☒ Safety ☐ Efficiency/Capacity ☐ Environment

Notes:

- *impact should be easily understandable by ATS/ATFM units and air operators and be characterized using the Mean opinion score (MOS) as per ITU-T recommendation P.800. MOS rates the quality of the voice signal in one of the following categories: excellent (5), good (4), fair (3), poor (2) and bad (1)*
- *volume of airspace (ATS) and trajectory descriptions should use FIXM (see http://fixm.aero/)*
- *description and presentation of impacts should be based on AIXM/IWXXM*
- *the forecast window of 24 hours was taken considering a 6 to 12 hours before takeoff for appropriate preparation of flights and ATFM/ATS units, a cruise of 12 hours and an additional margin of 6 hours*

HF communications through the polar region may be disrupted by sudden enhancement of high-energy particle precipitations in the polar cap region to enhance HF radio absorption (polar cap absorption: PCA).

Operational improvement SW-COM-2:	
a) Monitor the predicted impact of high-energy particle precipitations in the polar cap region on high frequency aeronautical mobile communications (controller / pilot) through the polar region over the next 24 hours in volumes of airspace (ATS) and along trajectories of the subscribed users (ATS units and airspace users) b) Warn concerned users when the predicted impact is very likely to affect the communications such that the MOS equals 3 (fair quality) and publish the description of affected volume of airspace (ATS) and trajectories c) Alert concerned users when the predicted impact is very likely to affect the communications such that the MOS equals 2 or less (poor or bad) and publish the description of affected volume of airspace (ATS) and trajectories	
☒Global ☒APAC	☒ Safety ☐ Efficiency/Capacity ☐ Environment

Notes:

- *impact should be easily understandable by ATS/ATFM units and air operators and could be characterized using the Mean opinion score (MOS) as per ITU-T recommendation P.800*
- *volume of airspace (ATS) and trajectory descriptions should use FIXM (see http://fixm.aero/)*
- *description and presentation of impacts should be based on AIXM/IWXXM*

These are global phenomena.

[ii] **Effect:** VHF communications may suffer from interferences by anomalous radio propagation associated with the sporadic E layer. The sporadic E-layer reflects VHF radio waves to cause long-distance propagation to reach beyond the radio horizon.

Examples/occurrences with their severity and frequency: to be developed (from AIG reports, ATS incident reports, operational experience, etc)

Monitoring and predicting the Es layer conditions are desirable.

Operational improvement SW-COM-3:	
a) Monitor the predicted impact of interferences by anomalous radio propagation associated with the sporadic E layer on very high frequency aeronautical mobile communications (controller / pilot) over the next 24 hours in volumes of airspace (ATS) and along trajectories of the subscribed users (ATS units and airspace users). b) Warn concerned users when the predicted impact is very likely to affect the communications such that the MOS equals 3 (fair quality) and publish the description of affected volume of airspace (ATS) and trajectories c) Alert concerned users when the predicted impact is very likely to affect the communications such that the MOS equals 2 or less (poor or bad) and publish the description of affected volume of airspace (ATS) and trajectories	
☒Global ☒APAC	☒ Safety ☐ Efficiency/Capacity ☐ Environment

Notes:

- *impact should be easily understandable by ATS/ATFM units and air operators and characterized using the Mean opinion score (MOS) as per ITU-T recommendation P.800*
- *volume of airspace (ATS) and trajectory descriptions should use FIXM (see http://fixm.aero/)*
- *description and presentation of impacts should be based on AIXM/IWXXM*

Sporadic E layer is a localized phenomenon.

[iii] **Effect:** L-band satellite communications may be disturbed by scintillations by irregularities in the ionosphere. In the low latitude region, small-scale irregularities in the ionosphere associated with plasma bubbles may cause scintillations in L-band satellite communication radio waves to cause degrading communications or lock-off of satellite signals.

Examples/occurrences with their severity and frequency: to be developed (from AIG reports, ATS incident reports, operational experience, etc)

As per [4] aviation users of the satellite segment in L-Band are Inmarsat, MTSAT and Iridium systems.

For Inmarsat and Iridium the potential impact regards ACARS, FANS and ATN communications, Electronic Flight Bag (EFB) data streaming and in the future the flight tracking systems.

Operational improvement SW-COM-4:
a) Monitor the impact of scintillations (plasma bubbles) in L-band satellite communication radio waves on data communication performance for: a. ACARS, FANS and ATN communications; b. Electronic Flight Bag (EFB) data streaming and; c. Flight tracking systems. b) Warn concerned users, including communication service providers, when the predicted impact will very likely degrade the performance of CPDLC, ADS-C, EFB or

Flight tracking service and publish the description of affected volume of airspace (ATS) and trajectories. c) Alert concerned users when the predicted impact is very likely to cause the loss of CPDLC, ADS-C, EFB or Flight tracking service and publish the description of affected volume of airspace (ATS) and trajectories	
☒Global ☒APAC	☒ Safety ☒ Efficiency/Capacity ☐ Environment

Plasma bubble is a localized phenomenon.

2.2 Navigation

Space Weather phenomena can affect propagation of radio waves used for aeronautical navigations. Following systems may be influenced:

[i] **Effects:** Effects of space weather phenomena are summarized in [3] as parts of GBSS vulnerability. Followings are among them

(a) Ionospheric propagation delay in GNSS signals is proportional to the ionospheric total electron contents (TECs). Different classes of ionospheric TEC disturbances can be error sources in GNSS. Phenomena that accompany TEC disturbances include the day-to-day variation of equatorial ionization anomaly, positive ionospheric storms associated with magnetic storms, and plasma bubbles.

(b) Ionospheric scintillation is caused by small-scale irregularities in the ionosphere. The effects are similar to those on the L-band satellite communications. In the low latitude region, it is associated with plasma bubbles.

(c) Solar radio burst is a sudden enhancement in the radio flux radiated by the sun. Enhancement in the solar radio flux in the GNSS signal bands degrades signal-to-noise ratio of GNSS signals to degrade the accuracy, and in the worst case cause lock-off of signals.

Monitoring and Predicting plasma bubbles are desirable for (a) and (b). Monitoring and predicting magnetic storms and resulted TEC variations are desirable for (a). Monitoring and predicting solar radio burst are desirable for (c).

Examples/occurrences with their severity and frequency: to be developed

Operational improvement SW-NAV-1:	
a) Monitor and predict the variation of TECs (ionospheric delays) and their disturbances over the next 24 hours in volumes of airspace (ATS), aerodromes and along trajectories of the subscribed users (ATS units, airport operators and airspace users). b) Warn concerned users, including RAIM prediction service suppliers, when the predicted impact will increase the a priori probability of ionospheric disturbances and publish the description of affected volume of airspace (ATS), aerodromes and trajectories.	
☒Global ☒APAC	☒ Safety ☒ Efficiency/Capacity ☐ Environment

Note: Current augmentation systems (SBAS, GBAS) assume a priori probability of ionospheric *disturbances as 1 (always there), which is very conservative. Such prediction would reasonably decrease the a priori probability and result in enhancing availability of GNSS -based systems.*

Operational improvement SW-NAV-2:	
a) Monitor and predict the impact of scintillations by plasma bubbles on GNSS signals over the next 24 hours in volumes of airspace (ATS), aerodromes and along trajectories of the subscribed users (ATS units, airport operators and airspace users). b) Warn concerned users, including RAIM prediction service suppliers, when the predicted impact will increase the a priori probability of ionospheric disturbances and publish the description of affected volume of airspace (ATS), aerodromes and trajectories.	
☒Global ☒APAC	☒ Safety ☐ Efficiency/Capacity ☐ Environment

Note: Since scintillations have direct impact on available satellites, this improvement could be a part of RAIM prediction.

Operational improvement SW-NAV-3:	
a) Monitor and predict the impact of solar radio bursts on GNSS signals over the next 24 hours in volumes of airspace (ATS), aerodromes and along trajectories of the subscribed users (ATS units, airport operators and airspace users). b) Warn concerned users, including RAIM prediction service suppliers, when the predicted impact will increase the a priori probability of ionospheric disturbances and publish the description of affected volume of airspace (ATS), aerodromes and trajectories.	
☒Global ☒APAC	☒ Safety ☐ Efficiency/Capacity ☐ Environment

[ii] **Effect:** VHF ground radio navigation aids may suffer from interferences by anomalous radio propagation associated with the sporadic E layer. The sporadic E-layer reflects VHF radio waves to cause long-distance propagation to reach beyond the radio horizon. Monitoring and predicting the Es layer conditions are desirable.

Examples/occurrences with their severity and frequency: to be developed (from AIG reports, ATS incident reports, operational experience, etc)

Sporadic E layer is a localized phenomenon.

Operational improvement SW-NAV-4:	
a) Monitor and predict the impact of sporadic Es layer conditions on actual navigation performance in volumes of airspace (ATS), aerodromes and along trajectories of the subscribed users (ATS units, airport operators and airspace users). b) Warn concerned users, including RAIM prediction service suppliers, when the predicted impact will increase the a priori probability of ionospheric disturbances and publish the description of affected volume of airspace (ATS), aerodromes and trajectories.	
☒Global ☒APAC	☒ Safety ☒ Efficiency/Capacity ☒ Environment

Note: Solar radio bursts are global phenomena, though it is strongest at sub-solar points on the Earth.

2.3 Surveillance

<u>Effect:</u> Surveillance systems which utilize GNSS such as ADS-B and ADS-C may be impacted by space weather phenomena as a consequence of space weather impact on GNSS.

<u>Examples/occurrences with their severity and frequency: to be developed (from AIG reports, ATS incident reports, operational experience, etc)</u>

Operational improvement SW-SUR-1:	
a) Monitor and predict the effects on ADS-B of space weather impact on GNSS in volumes of airspace (ATS) and along trajectories of the subscribed users (ATS units and airspace users). b) Warn concerned users when the positions reported will not meet the performance criteria and publish the description of affected volume of airspace (ATS) and trajectories. c) Alert concerned users when the predicted impact is very likely to cause the loss of ADS-B service and publish the description of affected volume of airspace (ATS) and trajectories.	
☒Global ☒APAC	☒ Safety ☒ Efficiency/Capacity ☐ Environment

Notes:

- *Ionospheric TEC variations and scintillations may degrade the position accuracy of GNSS-based position solutions which are piped to ADS-B outputs. Whether such impacts really exist has to be confirmed.*
- *As a first approach there would be no need for the ATS units/ATM systems to discriminate ionospheric effects from other effects affecting NUC or NIC,NAC, SIL. What is of interest is whether the positions reported do meet or not the performance criteria.*

Operational improvement SW-SUR-2:	
a) Monitor and predict the effects on ADS-C of space weather impact on GNSS in volumes of airspace (ATS) and along trajectories of the subscribed users (ATS units and airspace users). b) Warn concerned users, including communication service providers, when the predicted impact will very likely degrade the performance of ADS-C and publish the description of affected volume of airspace (ATS) and trajectories. c) Alert concerned users when the predicted impact is very likely to cause the loss of ADS-C service and publish the description of affected volume of airspace (ATS) and trajectories.	
☒Global ☒APAC	☒ Safety ☒ Efficiency/Capacity ☐ Environment

Notes:

- *Ionospheric TEC variations and scintillations may degrade the position accuracy of GNSS- based position solutions which are piped to ADS-C outputs. Whether such impacts really exist has to be confirmed.*
- *As a first approach there would be no need for the ATS units/ATM systems to discriminate ionospheric effects from other effects affecting FOM. What is of interest is whether the positions reported do meet or not the performance criteria.*

3. References

[1] WMO Space Programme SP-5, the Potential Role of WMO in Space Weather, April 2008.
[2] Concept of Operations for International Space Weather Information in Support of Aviation, Draft version 3.0, 6 December 2013.
[3] WP/21, Global navigation satellite system (GNSS) implementation issues, AN-Conf/12, November 2012.
[4] ICAO Doc 9718 AN/957 Handbook on Radio Frequency Spectrum Requirements for Civil Aviation Volume I

ADS-B IMPLEMENTATION STATUS IN THE APAC REGION

State/ Administration	ADS-B Ground Infrastructure and ATC System readiness or Implementation plan	Date of issue/effectiveness date of equipage mandate	Mandated Airspace and/or ATS-routes	Intended separation criteria to be applied	Remarks
AFGHANISTAN	ADS-B & Multi Lateration system installed.				subject to safety assessment
AUSTRALIA	A total of 45 ADS-B ground stations and 28 WAM stations are operational (Total 73) ATC readiness since 2004 ADS-B data sharing with Indonesia operational since 2/2011. ADS-B data sharing planned with PNG ASMGCS using multilateration and ADS-B is operational in Brisbane, Sydney, Melbourne and Perth An additional 15 ADS-B ground stations are planned in 2017-2020 period. Onesky replacing the current ATM system is expected to be fully operational in 2020 period.	2009/effective date of mandating in upper airspace 12/12/2013. A forward fit ADS-B mandate also applies from 2/2014 for all IFR aircraft at all flight levels. An ADS-B mandate for all IFR aircraft applies from 2/2017.	At/above FL290 from 12/2013 for domestic & foreign aircraft. All airspace for IFR aircraft from 2/2017	3NM and 5 NM surveillance separation. 3/2016 - Manual of ATC updated to include 3 nautical mile separation using ADS-B in terminal control unit. Vectoring allowed using ADS-B Precision Runway Monitoring for Sydney WAM	WAM is operating in Tasmania since 2010 with 5 NM separation service. WAM is also operating in Sydney for 3 NM separation service in TMA and for precision runway monitoring function.

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
BANGLADESH	Bangladesh has a plan to commission four ADS-B ground stations to be installed at Dhaka, Cox's Bazar, Saidpur and Barisal Airports by 2019. ADS-B data will be integrated with new ATS system at Dhaka.				
CAMBODIA	3 ADS-B ground stations installed at Phnom Penh, Siem Reap and Stung Treng City since 2011 and able to provide full surveillance coverage for Phnom Penh FIR. Cambodia is willing to share data with others.				
CHINA	5 UAT ADS-B stations used for flight training at CAFUC to be upgraded to support 1090ES by 2017. 310 ADS-B stations nationwide will deployed as 1st phase by the end of 2017.	NOTAM issued on ADS-B trial operation			ADS-B signal alone won't be used for ATC separation

State/ Administration	ADS-B Ground Infrastructure and ATC System readiness or Implementation plan	Date of issue/effectiveness date of equipage mandate	Mandated Airspace and/or ATS-routes	Intended separation criteria to be applied	Remarks
	1 ADS-B station operational in Sanya FIR since 2008. Sanya ATC system ready since July 2009 to support L642 & M771. Additional 3 ground stations deployed in 2015. Chengdu-Jiuzhai project finished in 2008 with 2 ADS-B stations Chengdu - Lhasa route surveillance project completed with 6 ADS-B stations using 1090ES since 2010. Trials operated from May 2011. 9 ADS-B stations deployed on the routes H15 and Z1 in 2015.				
HONG KONG CHINA	A larger-scale A-SMGCS covering the whole Hong Kong International Airport put into operational use in April 2009.	AIP supplement issued on 29 Oct.2013/12 Dec. 2013 as effective date.	L642/M771 ATS routes.	To be determined.	ADS-B signals being fed to ATC controllers under an operational trial programme.

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	Data collection/ analysis on aircraft ADS-B equipage in Hong Kong airspace conducted on quarterly basis since 2004. ADS-B trial using a dedicated ADS-B system completed in 2007. ADS-B out operations over PBN routes L642 and M771 at or above FL 290 within HK FIR was effective in December 2013 and within HK FIR at or above FL 290 is planned for December 2016. ADS-B ground station infrastructure completed in 2013. ADS-B trial using ADS-B signal provided by Mainland China to cover southern part of Hong Kong FIR commenced in				ADS-B operation in Hong Kong FIR re-scheduled for Dec. 2016. An AIP Supplement was issued on 29 Aug. 2014.

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	2010.				
MACAO, CHINA	Mode S MSSR coverage available for monitoring purposes.				Airspace – ATZ only
DEMOCRATIC PEOPLE’S REPUBLIC OF KOREA	ADS-B has been used as back-up surveillance of SSR since 2008.				
FIJI ISLANDS	ADS- B /multilateration ground stations installed. Situations awareness service provided in 2013. BY EMAIL	ADS-B mandate commencing form 31st December 2013			
FRANCE ***(French Polynesia)***	ATM system is ready for ADS-B sensors/Installation of 5 first GS expected at beginning of 2017. 2nd stage with implementation of 7 GS and associated VHF coverage.			5 NM for airspace under coverage.	
INDIA	ASMGCS (SMR + Multilat) is operational at Delhi, Mumbai, Chennai, Kolkata, Bangalore and Hyderabad Airports. ASMGCS is also being	AIP supplement issued on 17th April 2014 with effective date of implementation from 29th May 2014.			ADS-B in India to provide redundancy for radar and filling the surveillance gaps. ADS-B data trial operations

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	installed at 05 more international airports. ADS-B Ground Stations were installed at 21 locations across continental airspace and including Oceanic airspace at Port Blair. Procurement of 10 more ADS-B Ground stations is under consideration in 2016.. ATM automation systems at 22 ATC Centres are capable of processing ADS-B data and provide the information on Display.				commenced in 2015 in both Non-radar and radar environment, in Enroute & Terminal phases of flight for ATC purposes. AIP SUP 18 of 2014 issued
INDONESIA	30 Ground Station successfully installed. Since 2009, ATC Automation in MATSC has capabilities to support ADS-B application. ADS-B Task	On 24 July 2014 DGCA published AIRAC AIP Supplement No. 10/14 for using ADS-B for situation awareness effective from 18 Sep. 2014 to 25 June 2015. AIP Supplement on ADS-B Implementation (Tier-1)(mandate)	Mandate from Janaury 2018 for Class A airspace from FL290 to FL460	Intended to use for 5 NM separation	

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	Force team established to develop planning and action concerning ADS-B Implementation within Indonesia FIR ADS-B data sharing with Australia and Singapore.	being published with effective date on 25 June 2015.			
JAPAN	Multilateration Systems for surface monitoring have been implemented at eight airports PRM (WAM) has been implemented at Narita Airport. En-route WAM system is manufacturing and will be put into operation in FY2018 Plan to evaluate accuracy of ADS-B information and has intension to introduce ADS-B to the oceanic direction.				

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
LAO PDR.	2 ADS-B ground stations were installed in Vientiane and Luangprabang Int'l Airport in 2015 and the ADS-B data is fused with MSSR data target in the ATM Automation system. 3 additional ADS-B ground stations (DO-260B compliant) will be completed the installation at existing MSSR sites (Xiengkhouang, Savannakhet and Champasack) by 2016 to Q1 of 2017 to enhance the full ADS-B coverage of Lao FIR.				
MALAYSIA	Malaysia installing two (2) ADS-B ground stations in Genting Highland and Langkawi. The said ADS-B are expected to be commissioned by end of 2019. Malaysia revised the plan to start mandate ADS-B requirement for implementation	Revised Plan to issue mandate with target effective date by end of 2022.		ICAO approved surveillance separation.	

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	of ADS-B service for exclusive airspace/route without radar coverage within KL FIR by the end 2022. Specific Routes for ADS-B Implementation Plan: P574, N571, L510, P628, L645 & P627.				
MALDIVES	4 ADS-B stations installed in Nov. 2012 (2 at Male' Ibrahim Nasir Intl Airport, 1 at Kulhudhuffushi Island in the North and 1 at Fuah Mulah Island in the South to cover 95% of the FIR at/above FL290. Maldives' ADS-B is integrated with the ATM system (in November 2013), and under observation prior to commencing trials. Maldives has planned to share ADS-B data with its adjacent FIRs. Updated by email				Seaplane in Maldives equipped with ADS-B for AOC purpose. These seaplanes have ADS-B IN functions as well.

State/ Administration	ADS-B Ground Infrastructure and ATC System readiness or Implementation plan	Date of issue/effectiveness date of equipage mandate	Mandated Airspace and/or ATS-routes	Intended separation criteria to be applied	Remarks
MONGOLIA	Ten ADS-B ground stations for combination SSR and filled the surveillance gaps implemented in 2015 and integrated with ATM system and trial operation in early 2016.				
MYANMAR	ADS-B ground stations to be installed at Sittwe, Co Co Island by end of 2014 as 1st phase Yango , Lashio and Myeik -2015 as 2nd phase; Kengteng, Myitkyina in 2016. Completion of integration to Euro Cat. C. in 2014. Agreed to share ADS-B data with India, agreement on sharing being negotiated.				Supplement radar and fill the gaps to improve safety and efficiency ADS-C/CPDLC integrated in Yangon ACC since 2010.
NEPAL	ADS-B feasibility study conducted in 2007.				

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
NEW CALEDONIA	Three ADS-B ground stations commissioned in 2010 to cover international traffic at La tontouta airport serving Tontouta ACC & APP. It is used for Situation awareness and SAR.				
NEW ZEALAND	MLAT and ADS-B data is being used from the WAM system centered in the Queenstown area to provide surveillance coverage and surveillance separation (5 nm) over the southern half of the South Island of New Zealand. Additionally MLAT data from the Auckland MLAT system is used to provide airport surface movements at NZAA. The New Zealand Navigation and Airspace and Air Navigation Plan "New Southern SKY" issued in May 2014	New Zealand has plans to introduce ADS-B OUT mandates as follows: ADS-B OUT equipment requirement for all aircraft operating in controlled airspace above FL 245 from 1 January 2019 ADS-B OUT equipment requirement for all aircraft operating in controlled airspace from 1 January 2022. A forward fit requirement for ADS-B equipage on all newly registered aircraft in 2017. The Rule will not specify particular Technical Standing Orders (TSO), or transponder GNSS receiver models for position input into		5 NM Surveillance Separation in en-route airspace, and 3NM surveillance separation in terminal airspace.	

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
		ADS-B.			
PAKISTAN	Tender for procurement of 5 ADS-B stations issued to be installed at Pasni, Lakpass, Rojhan, Dalbandin and Laram-top. Contract expected to be finalized by end of 2015. These stations will be DO260B compliant and operational by end of 2017.				
PAPUA NEW GUINEA	Initially 8 ADS-B sites to be deployed across PNG to provide seamless coverage above FL285. First site to be installed May/June 2016, with remainder to be completed between May-July 2017. Up to an additional 7 sites to be rolled-out in the 2018/19 timeframe. Site location will be dependent on infrastructure, security and an	An ADS-B mandate is on CASA PNG roadmap, however legislation yet to be developed. The Australian mandates will largely drive equipage for overflights (e.g. East-Asia to Australia/South Pacific). Expectation is that PNGASL (the ANSP) will lead development of ADS-B mandate framework. Initial steps may include mandate	None	**Air Traffic Control** <u>Approach/Arrivals</u> 2017 – 5NM 2018 – 3NM (approach) <u>Upper Airspace (>FL245)</u> 2017/18 – Situational awareness. 2018/19 – 5NM Note: Implementation dictated by training requirements and new ATM	

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	analysis of Phase 1 site performance. In late 2016, PNGASL (ANSP) will be implementing a replacement ATM automation system. The system will support fusion of ADS-B and RADAR data. From 2017 onwards, PNGASL will be looking to share ADS-B data with Indonesia and Australia.	above F245 – but will depend on performance of Phase 1 ADS-B deployment. Country-wide mandate not envisaged before 2021/22.		system transition priorities. **Flight Service** Directed Traffic (FIS) 2017 – Situational awareness	
PHILIPPINES	Four (4) ADS-B ground stations (Manila, Palawan, Pangasinan and Zambales) with target date tocomplete by end 2016. ATM Center expected to be available in 2016.				
REPUBLIC OF KOREA	ADS-B implemented 2008 for SMC in Incheon International Airport. ROK is developing ADS-B system				

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	since 2010 through R&D group. The testbed at Gimpor Airport supporting both 1090ES and UAT, undergoing operational testing (2013-16). At Incheon Intl Airport, promotion of surface surveillance (2014-17) In 2nd phase from 2015 to 2016, ADS-B ground stations will supplement to the radar in the terminal area and fill up the gap between radar coverage. The last phase from 2017 to 2020, ADS-B will be deployed for entire Incheon FIR.				
SINGAPORE	The airport MLAT system was installed in 2007 and “far-range” ADS-B sensor was installed in 2009. ATC system has been processing ADS-B data since 2013.	AIC was issued on 28 December 2010/effective from 12 Dec.2013. AIP supplement published in Nov 2013 to remind operators of ADS-B exclusive airspace implementation. AIP updated in Jan 2015 to remove the need for ops	L642 and M771. At and above FL290. Also affect the following ATS routes N891, M753, L644 & N892	40nm on ATS routes L642, L644, M753, M771, N891 and N892 30nm implemented on 26th June 2014 on ATS routes L642, M753, M771 and N892; 20nm planned for end 2016	Safety case was completed end of November. 2013.

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
		approval and to include the FAA standard as an additional accepted means to meet the equipage requirements.			
SRI LANKA	Installation of five (05) ADS-B Ground Receiving stations have been re-planned to be completed by end of November 2016, with its commissioning & ATM System Readiness by end of December 2016.	Revised Date of Equipage mandate 31st Dec. 2016	All ATS Routes within Colombo TMA	Initially 5 nm within Approach Radar Coverage, 8 nm within Area Radar Coverage & Procedural Separation minima outside Radar Coverage.	Reduction of Terminal/En-route separation to 30 nm & Use of ADS-B alone for vectoring & separation only after safety assessment.
THAILAND	Multilateration implemented at VTBS in 2006, installed at VTBD in 2016 which to be implemented in 2017; and to be installed at VTCC and VTSP in 2017. ADS-B ground stations (DO-260B compliant) installed in Thailand for internal research & development project.	Plan to issue mandate with target effective date end of 2018.			

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	Thailand is currently undergoing the operational approval process to have ADS-B as part of surveillance infrastructure. Nationwide WAM+ADS-B covering all en-route and TMA airspace to be installed in 2017. New ATM System to be operational in 2017 will be capable of processing ADS-B and WAM data and integration of data from multiple sensor types.				
TONGA	Trial planned for 2017				
UNITED STATES	As of 1 April 2016, the “baseline” set of Service Volumes planned by the FAA in 2007 are operational, using data from over 600 radio sites installed by Harris. Since 2007, FAA has planned and funded activities	The U.S. ADS-B Out rule (14 CFR 91.225 and 14 CFR 91.227) was issued in May 2010 and specifies that the ADS-B Out mandate is effective on 1 January 2020.	Class A, B, and C airspace, plus Class E airspace above 10,000 ft MSL. See 14 CFR 91.225 for details.	The U.S. is using both terminal and en route (5nm) separation criteria, depending on the specific airspace and available surveillance information. Terminal separation includes the following separation	

State/ Administration	**ADS-B Ground Infrastructure and ATC System readiness or Implementation plan**	**Date of issue/effectiveness date of equipage mandate**	**Mandated Airspace and/or ATS-routes**	**Intended separation criteria to be applied**	**Remarks**
	to activate additional Service Volumes that Harris will service using additional radio sites; all but 16 of these radio sites have been installed and are operational as of 1 April 2016. As of 1 April 2016, 135 of the 226 U.S. air traffic control facilities are using ADS-B for ATC separation; all En Route Centers and major Terminal facilities are using ADS-B for ATC separation; all remaining facilities are planned to be using ADS-B by 2019.			criteria: - 3nm - 2.5nm - indepen-dent parallel approach operations down to 4300 ft centreline separation - dependent parallel approach operations down to 2500 ft centreline separation (currently 1.5 nm diagonal distance).	
VIET NAM	Two phases ADS-B implementation plan adopted. Phase 1 implemented in March 2013. Phase 2 commenced in 2015 for whole lower and upper Hanoi FIR and 2018 for Ho Chi Minh FIR	AIC issued on 20 June 2013/ADS-B mandating effective from 12 December 2013 in Ho Chi Minh FIR.	M771, L642, L625, N892, M765, M768, N500 and L628 At/above FL290.		Operators required to have operational approval from State of aircraft registry.

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INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ADS-B IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT

Edition ~~8.0~~ 9.0 – ~~September 2015~~April 2016

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

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) 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 ADS-B Study and Implementation Task Force.

When an amendment has been agreed by a meeting of the ADS-B Study and Implementation Task Force 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

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1.6 AIGD REQUEST FOR CHANGE FORM

RFC Nr:	

Please use this form when requesting a change to any part of this AIGD. 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/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 :**	

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 (3rd 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 2015	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 …

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
ARINC	Aeronautical Radio Incorporate
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
NAC	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

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 95% of the time (See DO229c).
NAC (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 16/7/12	July 2005	ICAO	
2	Annex 4: Aeronautical Chart	Eleventh Edition including Amendment 56 dated 12/7/10	July 2009	ICAO	
3	Annex 10: Aeronautical Telecommunications, Vol. IV – Surveillance Radar and Collision Avoidance Systems	Fourth Edition Including Amendment 87 dated 12/7/10	July 2007	ICAO	
4	Annex 11: Air Traffic Services	Thirteenth Edition including Amendment 48 dated 16/7/12	July 2001	ICAO	
5	Annex 15: Aeronautical Information Services	Thirteen Edition	July 2010	ICAO	
6	PAN-ATM (Doc 4444/ATM501)	Fifteen Edition including Amendment 4 applicable on 15/11/12	2007	ICAO	
7	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	
8	Doc 9859 Safety Management Manual (SMM)	Third Edition	2012	ICAO	
9	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	
10	Regional Supplementary Procedures (Doc 7030)	Fifth Edition including Amendment 5 dated 22/7/11	2008	ICAO	

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 ~~(DO 260B in 2016)~~ 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 on the ICAO APAC website “http://www.icao.int/APAC/Pages/edocs.aspx” 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 though 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 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.

5.1.4.4.3 Acquisition of Mode 3/A code for DO-260 aircraft through Mode S downlink~~in Mode A/C SSR environment~~

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 Mode S aircraft address to perform association between ADS-B and Mode S radar targets without ambiguity.

5.1.4.4.4~~3~~ 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" for reference by States.

5.1.4.5 Additional Functional Requirements for ADS-B Integration

5.1.4.5.1 The following ~~additional~~list of functions ~~al requirements are to~~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 ~~should~~ could be adaptable;
- For ADS-B aircraft, receipt of the Mode S conspicuity code ~~should~~could trigger use of the Flight ID / Aircraft Address for flight plan correlation;

- If, due to sensor or aircraft capability limitation, no SSR code is received for an aircraft, the system ~~should~~could use Flight ID/ Aircraft Address for track correlation;

- For correlation based on Flight ID, the received ID ~~should~~could exactly match the ACID of the flight plan;

- For correlation based on Aircraft Address, the received address ~~should~~could match the address entered in the flight plan field 18 CODE/ keyword;

- The system ~~should~~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 Aircraft Address from the track does not match the code given in the flight plan field 18 CODE/ keyword;

- The system ~~should~~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 ~~should~~could only apply to data received at or above the adapted NUCp, NACp, NIC, and/or SIL thresholds;

- The system ~~should~~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 ~~should~~could only be displayed if there are no other surveillance sources available;

- The system ~~should~~could allow the adaptation of ADS-B emergency codes to map to SPC Mnemonics;

- The system ~~should~~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 ~~should~~could generate a conformance alert if the Selected Altitude and the Cleared Flight Level do not match.

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.

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;
43) functional processing;
54) functional performance; and
65) 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

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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 started to introduce ADS-B for the provision of Air Traffic Services, including 'radar-like' 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.
~~Checklist of common items or parameters 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 ADS-B SITF members. The PRS tracks problem reports and publish information from those reports to ADS-B SITF members. Problem resolution is the responsibility of the appropriate ADS-B SITF members.

The PRS Administrator shall:

a) prepare consolidated problem report summaries for each ADS-B SITF meeting;

b) collect and consolidate ADS-B Problem Reports; and

c) maintain a functional website (with controlled access) to manage the problem reporting function.

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 ADS-B SITF. 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 ADS-B SITF. 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 ADS-B SITF; 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 ADS-B SITF 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 #**
Date UTC		**Time UTC**	
Registration		**Aircraft ID**	
Flight ID		**ICAO 24 Bit Code**	
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 ADS-B SITF.
Date UTC	UTC date when the event occurred.
Time UTC	UTC time (or range of times) at which the event occurred.
Registration	Registration number (tail number) of the aircraft involved.
Aircraft ID (ACID)	Coded equivalent of voice call sign as entered in FPL Field 7.
ICAO 24 Bit Code	Unique 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.

7.9 ADS-B PERFORMANCE REPORT FORM			
Originating Organization			
Date of submission		**Originator**	
Report Period			
TECHNICAL ISSUES			
OPERATIONAL ISSUES			
GENERAL COMMENTS			

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" which is available on the ICAO APAC website at: http://www.icao.int/APAC/Documents/edocs/cns/ADSB_ServicePer.pdf

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 ~~for~~that could be considered for monitor~~ing~~ing 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. Ie: 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.

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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

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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 equippage rates of ADS-B avionics. However the equippage 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 equippage 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 Amendment Order (No. 1) 2009, Civil Aviation Order 82.1 Amendment Order (No. 1) 2009, Civil Aviation Order 82.3 Amendment Order (No. 2) 2009, Civil Aviation Order 82.5 Amendment Order (No. 2) 2009 and Miscellaneous Instrument CASA 41/09 – Direction – use of ADS-B in foreign aircraft engaged in private operations in Australian territory
"http://www.comlaw.gov.au/Details/F2012C00103/Download"

(b) Civil Aviation Department (CAD) of Hong Kong, China
Aeronautical Information Publication Supplement No. 13/13 dated 29 October 2013
"http://www.hkatc.gov.hk/HK_AIP/supp/A13-13.pdf"

(c) Civil Aviation Authority of Singapore (CAAS)
Aeronautical Information Publication Supplment No. 254/13 dated 6 November 2013
"http://www.caas.gov.sg/caasWeb2010/export/sites/caas/en/Regulations/Aeronautical_Information/AIP_Supplements/download/AIPSUP254-13.pdf"

(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 8th June 2018, 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 version [1].

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 NUC/NIC/SIL categorization of the accuracy and integrity of the horizontal position data. This figure is determined from NIC/ NAC/ 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.

[1] Subject to endorsement by APANPIRG/26 in September 2015

9.3.3 GNSS Integrity Prediction Service

Early implementations of ADS-B are expected to use 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 Monitoring Agencies Coordination Group (RMACG), 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.

9.4 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 for 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 the equivalency with radar is preserved.

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 s

- 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 date. Aircraft identification is critical, so it must be entered carefully. Punching in the wrong characters can lead to ATC confusing once 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 firespotter 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 AIRCAFT 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 NAC 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, stipulated in the Regional Supplementary Procedures Doc 7030, 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:

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 NAC 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.

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 no comply with :

(a) EASA AMC 20-24; or

(b) the equivalent configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia; or

(c) Installation in accordance with the FAA AC No. 20-165 – Airworthiness Approval of ADS-B;

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 NAC or SIL.

Note:

1. It is considered equivalent to deactivation if NUCp or NIC or NAC 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 NAC 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.

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.

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.

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.

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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 APANPIRG has also requested and the ICAO has agreed to support establishing a centralized database to be hosted by the ICAO Regional Sub-office (RSO) for sharing the monitoring results in order to enhance safety for the Region. The specification for the database and relevant access procedures are being developed by the ADS-B Study and Implementation Task Force, and will be shared with States in due course.

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.

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 safety, 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) NUC 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, NAC, 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 mismatch[1] 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.

[1] A missing Flight ID, or a Flight ID with only "spaces" should not be considered a mismatch.

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 :-

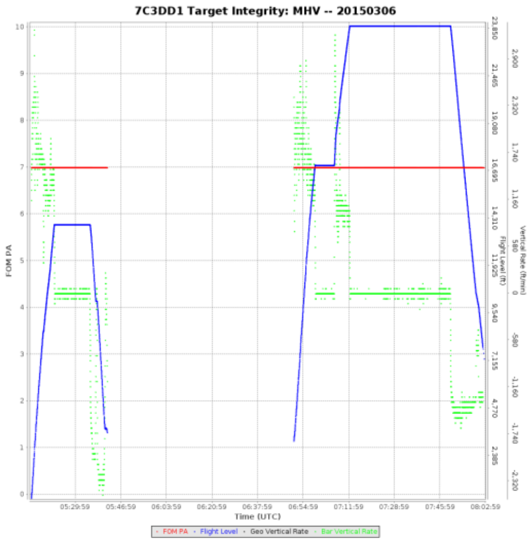
(a) Deviation between ADS-B reported position and independent referenced radar position is greater than 1NM[2], with the indication of good positional quality in the quality indicators for more than 5% of total number ADS-B updates. A sample screen shot of a system performing the analysis automatically is given at Attachment B for reference.

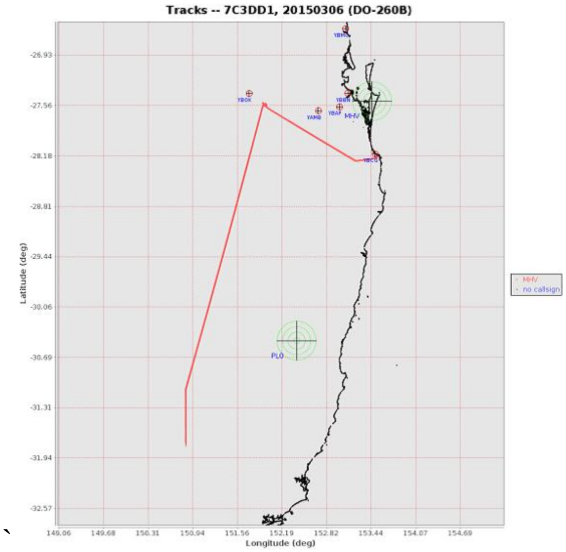
5.2 Managing and Processing Deficiencies

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 NUC/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 :-

[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 (0.5NM < HPL < 1NM) for 3NM aircraft separation use, on assumption that radar targets are close to actual aircraft position. The values of ADS-B quality indicators (NUC, NAC, 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-turning 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 ~~will not be available in the near future because of their commitment to~~is available in their DO260B ~~development~~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.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				An additional partial workaround is : 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 ~~will be available in 2014~~is available from December 2015. This new transponder ~~will~~ does not ~~exhibit~~ have ~~the~~ 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

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				transmission. 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)	**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 “Dynon 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
		b) As the aircraft enters 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,	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
	QFA7550, QFA7552, 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	Design error reports integrity	**No.**	Can be treated in the same manner as

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	report integrity too conservatively	one value worse than reality	In poor GPS geometry cases the ATC system could discard the data when the data is in fact useable. Will be perceived as loss of ADS-B data.	a loss of transponder capability.
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 24 bit code	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

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				NUC occurs on certain airframe and 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

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				when unexpected low NUC 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 >= "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 >=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 NUC	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.	**Yes.** Misleading position presentation which is typically detected by ATC observing aircraft "off track" when in fact it is "on-track".	In December 2015, Boeing and Rockwell Collins released the DO-260B upgrade for the B787 fleet which fixes the extrapolation issue as well as adding DO-260B support to the airframe. Service Bulletin with no cost has been issued by Boeing to encourage operator to accomplish the update as soon as possible. In addition, 787 Type Certification has been amended to include the software upgrade. The upgraded ADS-B Out function is compliant with FAA AC 20-165A, EASA CS-ACNS Subpart D (Surveillance) and TSO-C166b. ~~Problem identified and fix will be provided by Boeing at the same time as the availability of DO260B upgrade – late 2015.~~
19	A number of airlines have reported or experienced ADS-B outages for complete flight sectors in A330 aircraft. Appears as	Being actively investigated. One airline has implemented on-board recording which confirms that the MMRs are not providing HIL/HPL to	**No.** Equivalent to a failed transponder.	Aircraft must be managed procedurally if outside radar coverage.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	low reliability ADS-B and has afflicted both A & B side at same time.	the transponder whilst continuing to provide HFOM, GPS alt etc		
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 AESS. Consequently, the current AESS 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 AESS standard release; planned for 2017.”. Only a problem for arriving aircraft on surface surveillance systems.

Figure 1 - Track Jumping problem with TPR901

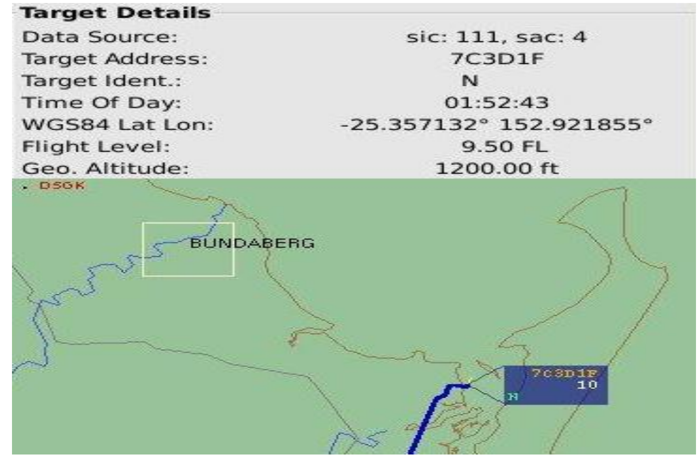


Figure 3 - Garmin "N" Flight ID problem

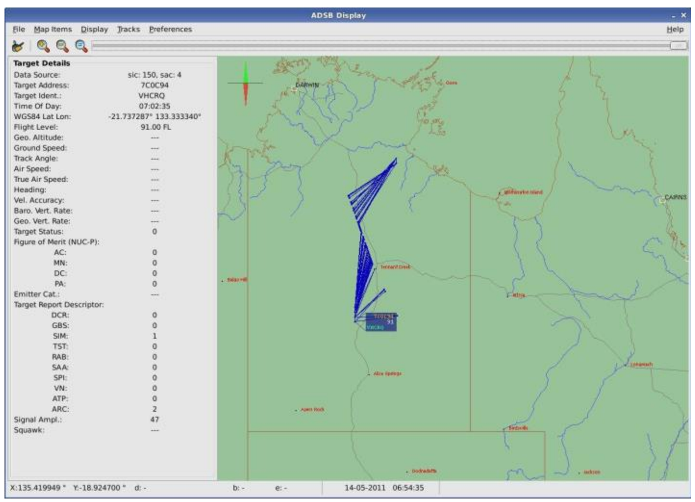


Figure 2 - Rockwell Collins TDR94 Old version. The pattern of erroneous positional data is very distinctive of the problem

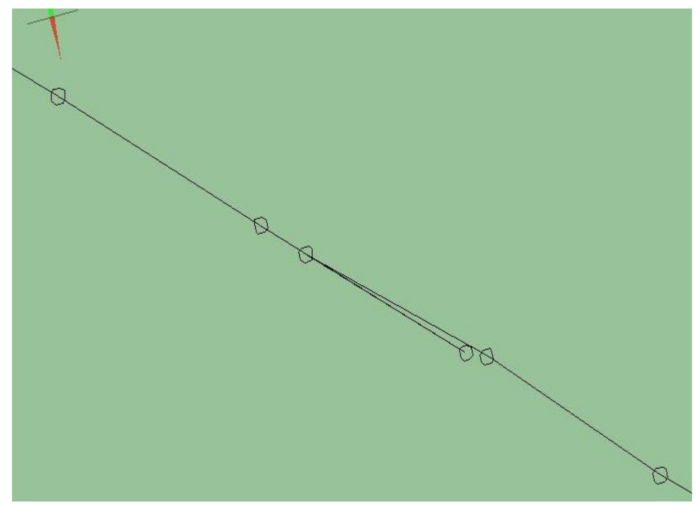


Figure 4 - Occasional small position jump backwards

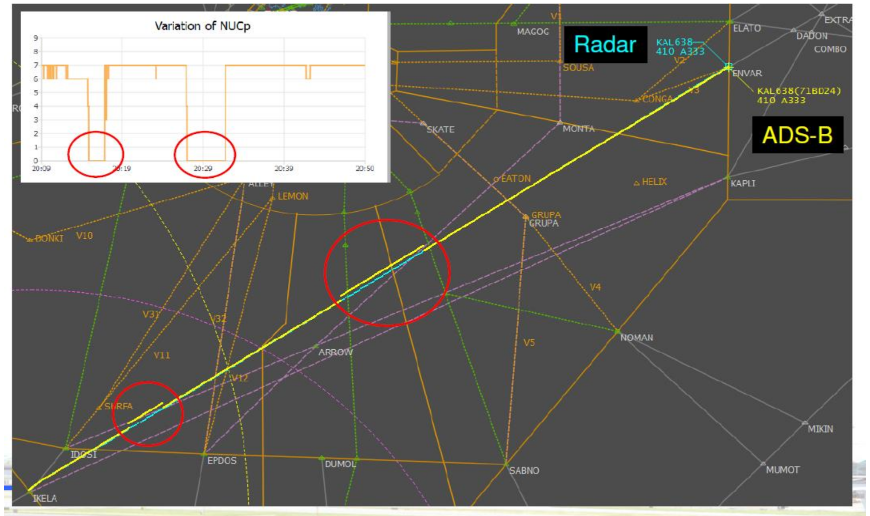


Figure 5 - NUC value toggling

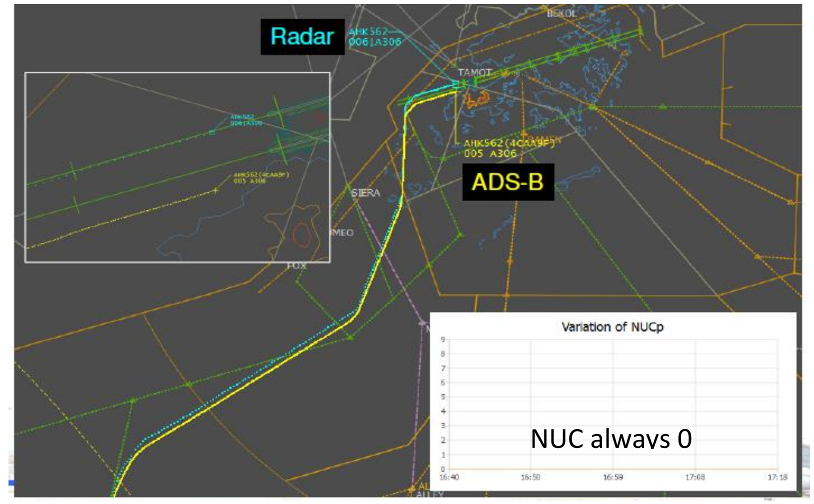


Figure 6 – Consistent low NUC

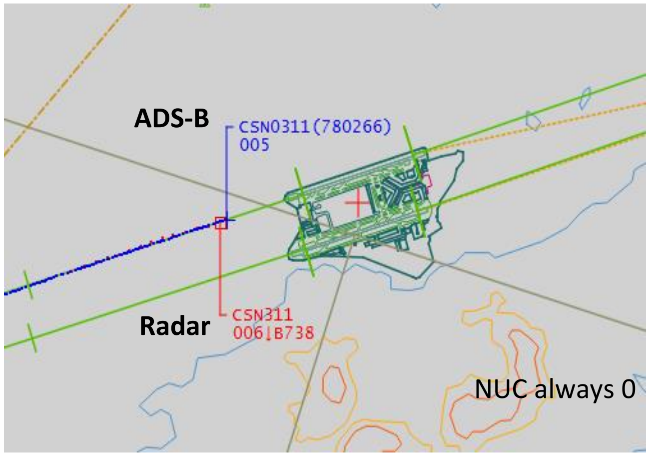


Figure 7a - Additional zero inserted

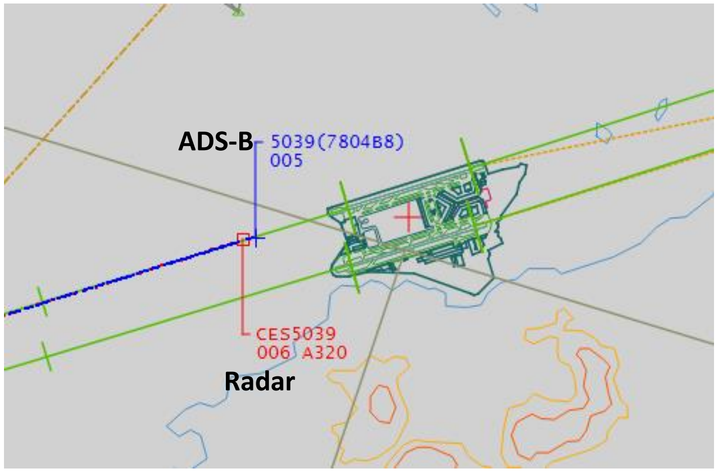


Figure 7b - ICAO Airline Designator Code dropped

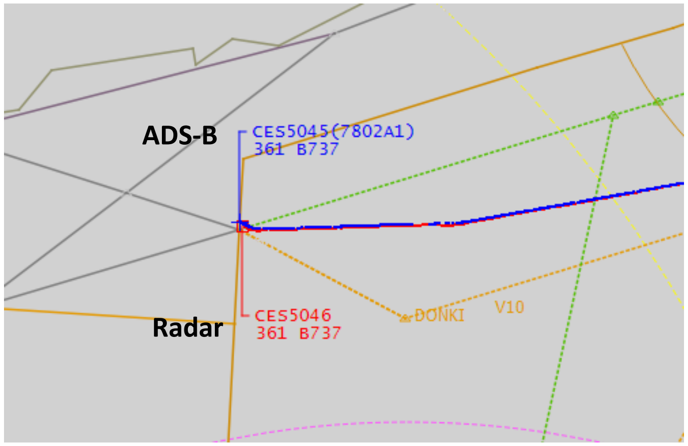


Figure 7c - Wrong numerical codes entered

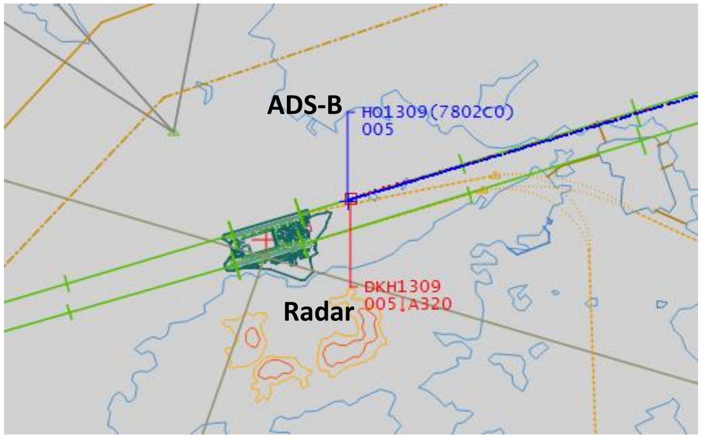
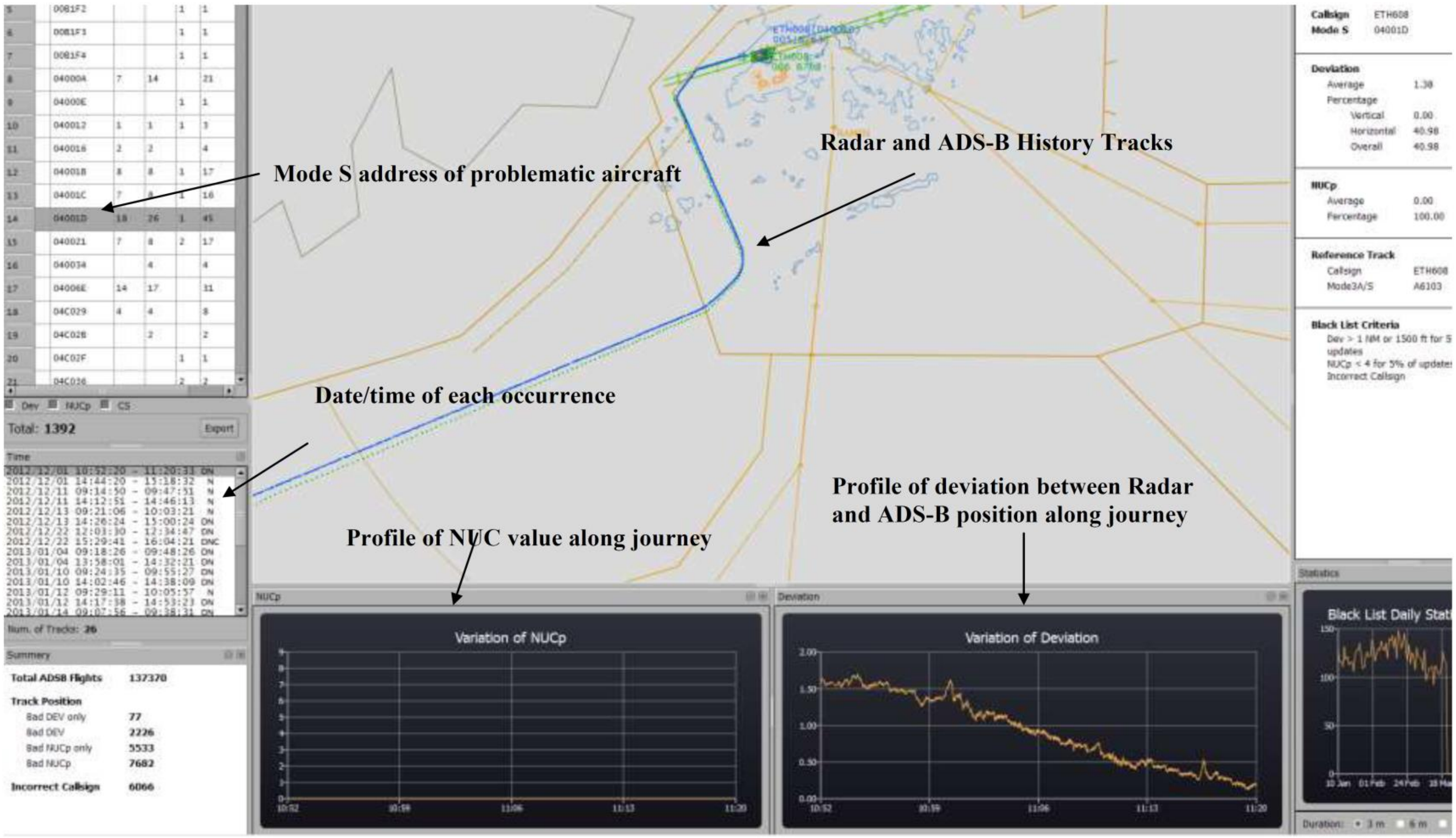


Figure 7d - IATA Airline Designator Code used

Attachment B - Sample screen shot of a system to monitor and analyse performance of ADS-B avionics



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
- 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 NAC/NIC/NUC Values
- Presence of Geometric Altitude
- Correctness of 24-bit Code
- 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 24-bit address
- Display of data block

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 APANPIRG has also requested and the ICAO has agreed to support establishing a centralized database to be hosted by the ICAO Regional Sub-office (RSO) for sharing the monitoring results in order to enhance safety for the Region. The specification for the database and relevant access procedures are being developed by the ADS-B Study and Implementation Task Force, and will be shared with States in due course.

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.

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 safety, 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) NUC 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, NAC, 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 mismatch[1] 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.

[1] A missing Flight ID, or a Flight ID with only "spaces" should not be considered a mismatch.

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 :-

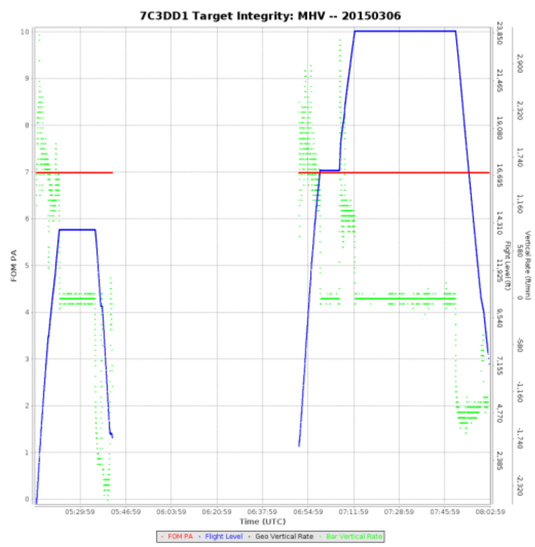
(a) Deviation between ADS-B reported position and independent referenced radar position is greater than 1NM[2], with the indication of good positional quality in the quality indicators for more than 5% of total number ADS-B updates. A sample screen shot of a system performing the analysis automatically is given at Attachment B for reference.

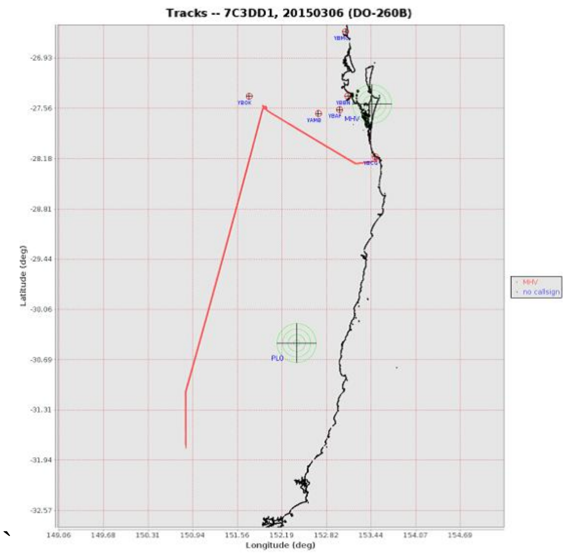
5.2 Managing and Processing Deficiencies

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 NUC/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 :-

[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 (0.5NM < HPL < 1NM) for 3NM aircraft separation use, on assumption that radar targets are close to actual aircraft position. The values of ADS-B quality indicators (NUC, NAC, 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-turning 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 ~~will not be available in the near future because of their commitment to~~is available in their DO260B ~~development~~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.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				An additional partial workaround is : 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 ~~will be available in 2014~~is available from December 2015. This new transponder ~~will~~ does not ~~exhibit~~ have ~~the~~ 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

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				transmission. 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)	**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 "Dynon 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
		b) As the aircraft enters 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,	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
	QFA7550, QFA7552, 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	Design error reports integrity	**No.**	Can be treated in the same manner as

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	report integrity too conservatively	one value worse than reality	In poor GPS geometry cases the ATC system could discard the data when the data is in fact useable. Will be perceived as loss of ADS-B data.	a loss of transponder capability.
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 24 bit code	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

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				NUC occurs on certain airframe and 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

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				when unexpected low NUC 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 >= "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 >=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 NUC	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.	**Yes.** Misleading position presentation which is typically detected by ATC observing aircraft "off track" when in fact it is "on-track".	In December 2015, Boeing and Rockwell Collins released the DO-260B upgrade for the B787 fleet which fixes the extrapolation issue as well as adding DO-260B support to the airframe. Service Bulletin with no cost has been issued by Boeing to encourage operator to accomplish the update as soon as possible. In addition, 787 Type Certification has been amended to include the software upgrade. The upgraded ADS-B Out function is compliant with FAA AC 20-165A, EASA CS-ACNS Subpart D (Surveillance) and TSO-C166b. ~~Problem identified and fix will be provided by Boeing at the same time as the availability of DO260B upgrade – late 2015.~~
19	A number of airlines have reported or experienced ADS-B outages for complete flight sectors in A330 aircraft. Appears as	Being actively investigated. One airline has implemented on-board recording which confirms that the MMRs are not providing HIL/HPL to	**No.** Equivalent to a failed transponder.	Aircraft must be managed procedurally if outside radar coverage.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	low reliability ADS-B and has afflicted both A & B side at same time.	the transponder whilst continuing to provide HFOM, GPS alt etc		
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 AESS. Consequently, the current AESS 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 AESS standard release; planned for 2017.”; Only a problem for arriving aircraft on surface surveillance systems.

Figure 1 - Track Jumping problem with TPR901

Figure 3 - Garmin “N” Flight ID problem

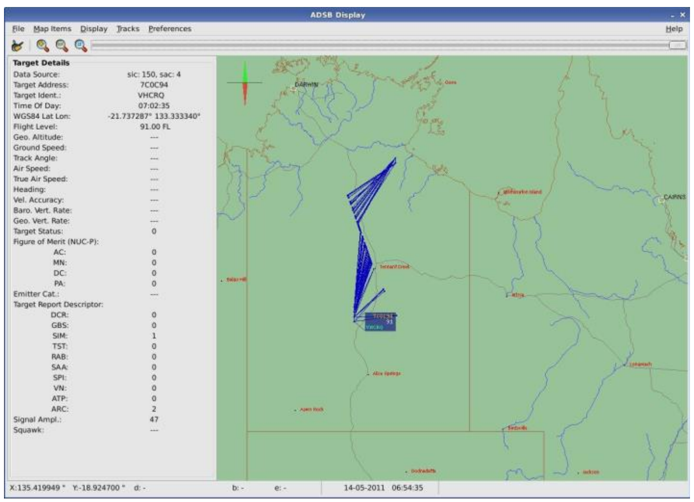


Figure 2 - Rockwell Collins TDR94 Old version. The pattern of erroneous positional data is very distinctive of the problem

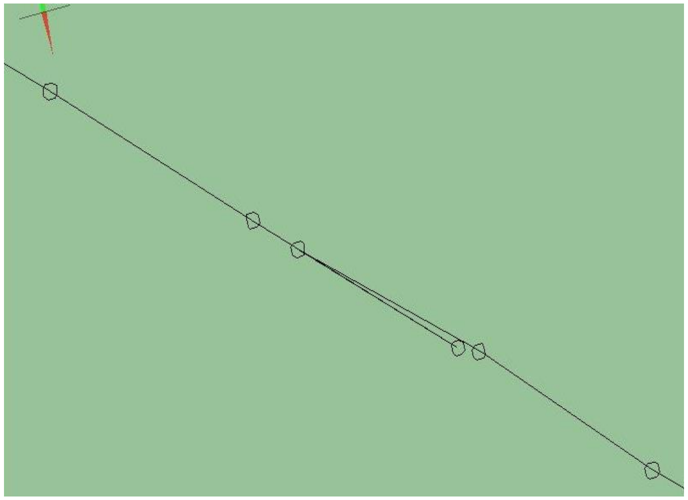


Figure 4 - Occasional small position jump backwards

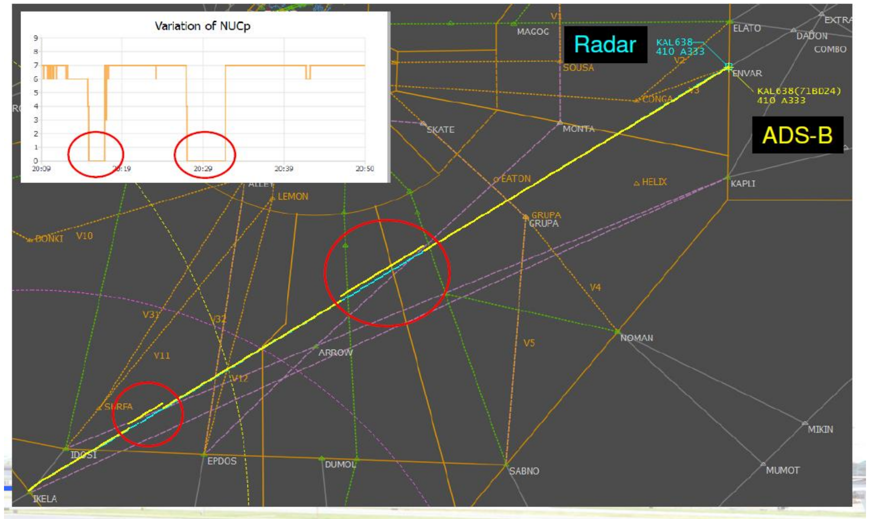


Figure 5 - NUC value toggling

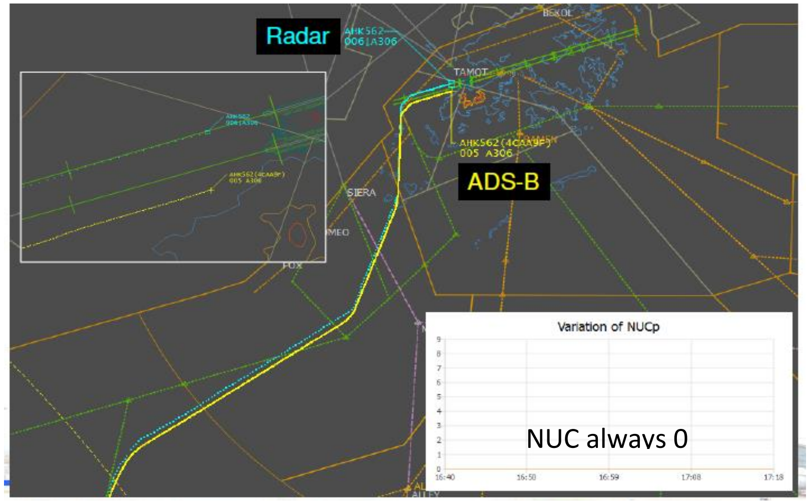


Figure 6 – Consistent low NUC

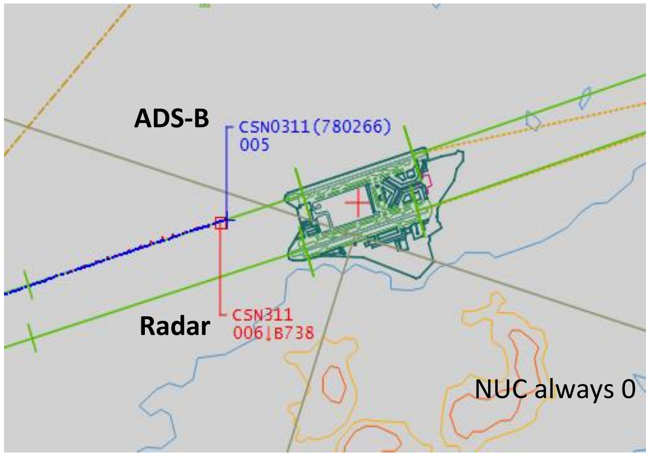


Figure 7a - Additional zero inserted

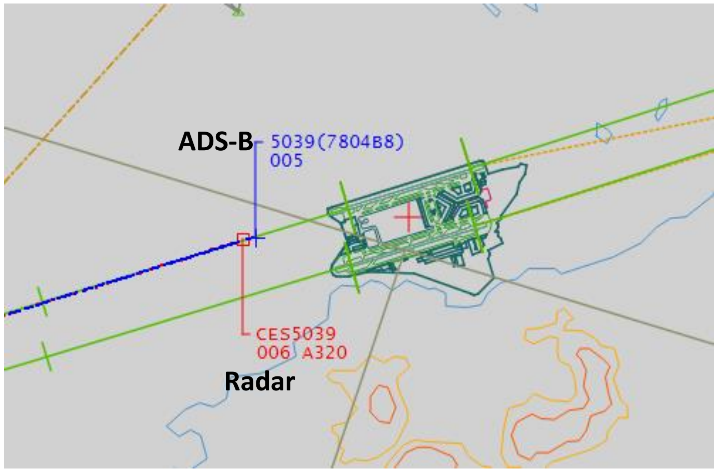


Figure 7b - ICAO Airline Designator Code dropped

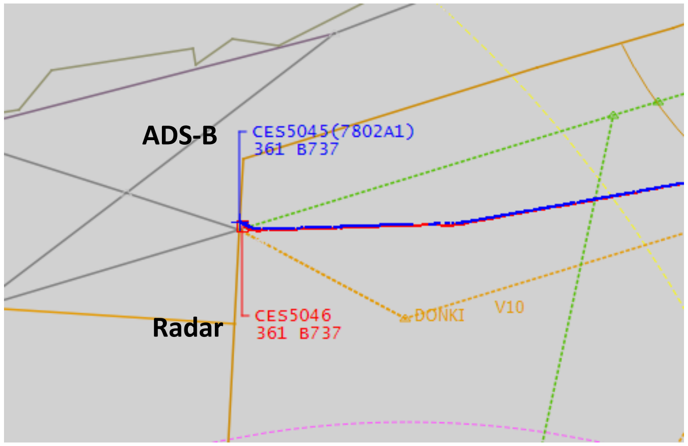


Figure 7c - Wrong numerical codes entered

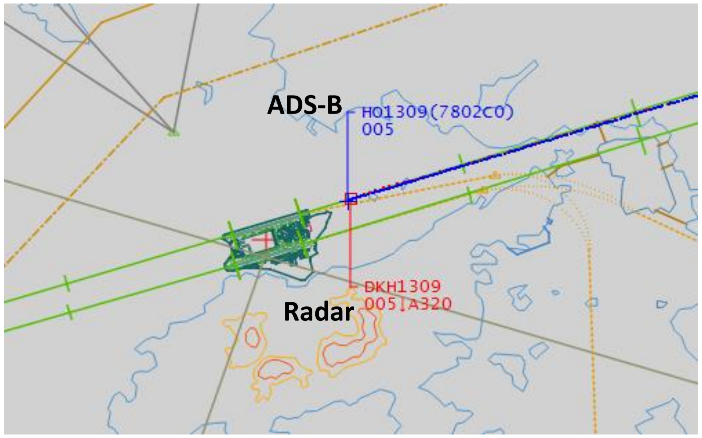
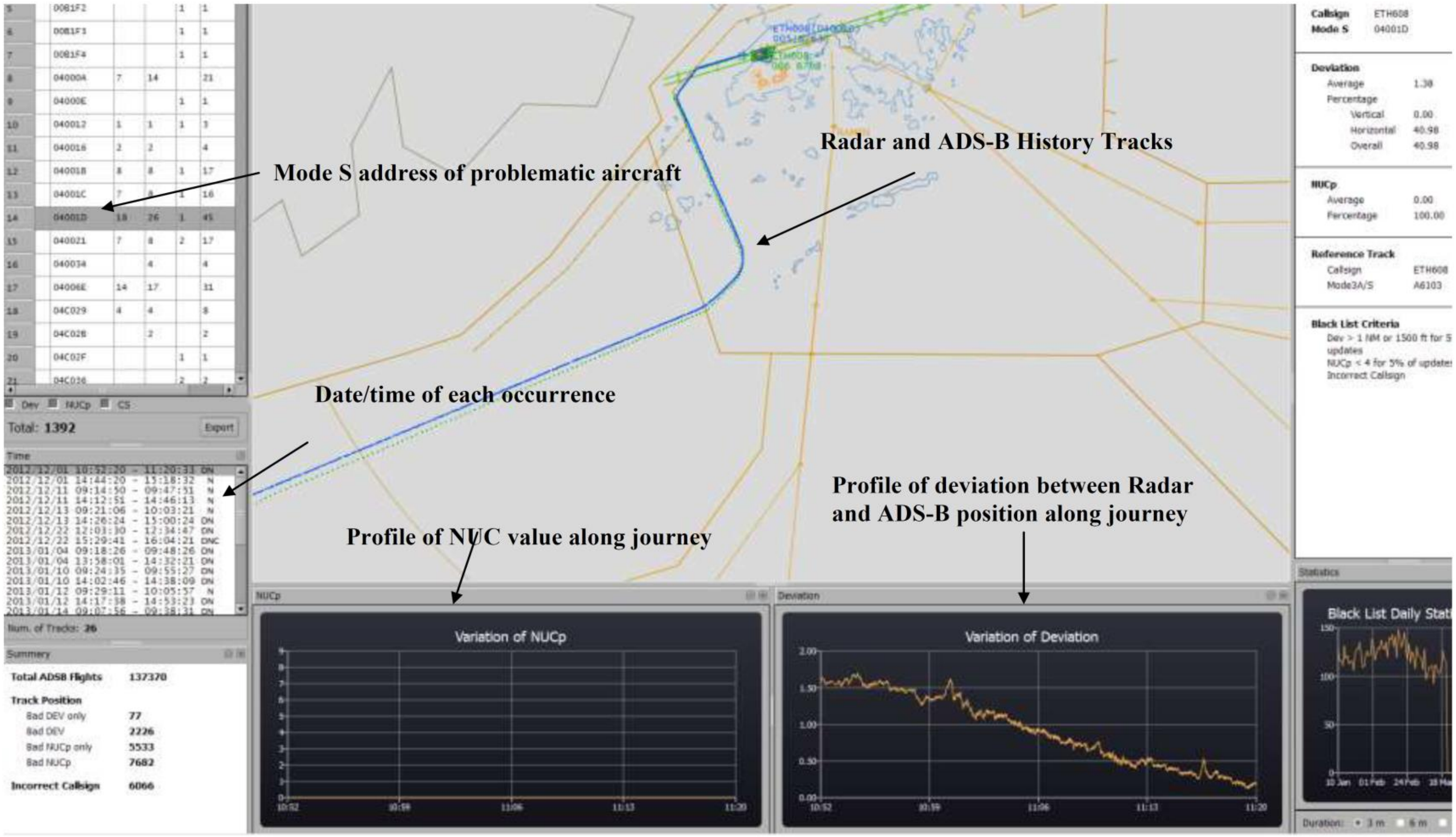


Figure 7d - IATA Airline Designator Code used

Attachment B - Sample screen shot of a system to monitor and analyse performance of ADS-B avionics



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
- 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 NAC/NIC/NUC Values
- Presence of Geometric Altitude
- Correctness of 24-bit Code
- 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 24-bit address
- Display of data block

REVISED SURVEILLANCE STRATEGY FOR THE APACASIA/PACIFIC 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. 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, noting that in the longer term an additional link type may be required;

6. Use of surveillance systems that do not require GNSS SSR and ADS-C will continue to meet many critical surveillance needs for the foreseeable future;

7. SARPs, PANS and guidance material for the use of ADS-B have been developed;

8. Mode S and ADS-B avionics (including DAPs) and ground processing systems are available;

9. ADS-B IN applications and equipment are now available in commercial airliners and ICAO ASBUs include ADS-B IN applications;

10. There are continuing significant pressures on the radio spectrum for purposes outside aviation, particularly in the primary radar spectrum; and

11. ADS-B security issues are addressed by the regional guidance material and 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, 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 ADS-B, Wide Area Multilateration and Mode S SSR based on operational requirements;

6. Make full use of SSR aircraft Mode S capabilities where suitable surveillance systems are available to reduce reliance on 4-digit octal codes. Mode S capabilities such as DAPs should also be used to support ATM services where appropriate;

7. Make use of ADS-C alternative technologies (e.g. ADS-C) where technical constraint or cost benefit analysis does not support the use of ADS-B, SSR or Multilateration;

8. Make use of Multilateration for surface, terminal and area surveillance where appropriate and feasible;

9. Closely monitor ADS-B OUT avionics developments such as Version 2 (DO260B) equipage rates and space-based ADS-B application programs. At an appropriate time (circa 201~~8~~6) APAC States –should review progress and consider development of transition plans where cost/benefit studies indicate positive advantages for the region;

10. Carefully monitor ADS-B IN development and cost benefits to ensure that ASIA/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. Monitor the outcomes of the Global Aircraft Tracking initiatives and ensure they are included in the Regional- strategy for implementation;

13. Implementation of surveillance capability should also include consideration of contingency surveillance -requirements; and

14. Monitor development of surveillance systems to support integration of UAS including RPAS operations .

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Note 1:

a) *Version 0 ES as specified in Annex 10, Volume IV, Chapter 3, Paragraph3.1.2.8.6 (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 (including provisions for new set of 1 090 MHz extended squitter (ES) messages and traffic information service – broadcast (TIS-B) being developed by the Aeronautical Surveillance Panel (ASP) and scheduled to be incorporated in Annex 10 Vol. IV – Surveillance and Collision Avoidance System as part of Amendment 86 with target applicable date in November 2013. (Equivalent to DO260B and EUROCAE ED-102A which were issued in December 2009)*~~ *Version 2 ES as specified in Chapter 4 of* Technical Provisions for Mode S Services and Extended Squitter *(ICAO Doc 9871) (Equivalent to DO260B)*.

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Interim Report of APAC/NAT Inter-regional ADS-C RITF

1. The First Meeting of the ICAO APAC/NAT Inter-regional ADS-C Reporting Interval Task Force (ADS-C RITF/1) was held from 21 to 23 June 2016 in the ICAO EUR/NAT Office Paris, France. A few teleconferences were held before the first meeting of the Task Force.

2 The meeting reviewed the objectives of TOR and noted that the task (b) of TOR was to determine a minimum ADS-C periodic reporting interval that would be technically feasible under specified conditions in support of performance based reductions in longitudinal separation minimum. The meeting noted that the ToR tasks were challenging for the reasons listed in the interim report of the Task Force.

3 The Meeting reviewed the ANSPs baseline table providing statistical data collected by the APAC and NAT ANSPs on the data link usage, ADS-C downlink message types, data link messages by media and satellites. The Meeting noted that the Table was very useful by providing a baseline document describing the current system usage. There was general agreement that the collected statistics would be useful to the CSP and SSP with some clarification needed on several of the parameters. It was noted that expected data for Singapore and Gander were missing from the Table.

6.46 While the collected data was determined to be useful, it was ultimately concluded that the data would not be used for the intended purpose of investigating current system limits as part of the ADS-C RITF activities due to clarification from the CSP and SSP on why they are not able to conduct such an activity for their aggregate system. However, the CSP and SSP expressed an interest in refining the data collected and using it for the purpose of designing system changes to accommodate planned changes in separation and the corresponding increase in ADS-C messages.

6.47 The Meeting also reviewed the scenarios template for APAC and NAT that had been developed during previous teleconferences of the ADS-C RITF. It was noted that operational concepts may differ from ANSP to ANSP. Further information was needed regarding anticipated increases in regional traffic levels and plans for increase in ATS message usage connected with anticipated separation reductions.

6.48 In reviewing the scenarios, the Meeting noted that the NAT DLM was aiming at 95% FANS 1/A equipage by 2020. It was agreed that 95% equipage by 2020 will be assumed for simplification for the ADS-C RITF studies. It was also noted that the ongoing implementation of the ground based ADS-B in the NAT and planned implementation of the space based ADS-B, will have impact on the ADS-C usage and system load.

6.49 The Meeting was provided with information by Inmarsat on the Australian Enhanced Flight Tracking Evaluation project, its conclusions and methodology used. The Meeting noted that although the project was focused on the implementation of 15 minutes ADS-C reporting intervals in support of new ICAO provisions on normal flight tracking, the methodology could be used as a model for ANSPs in designing a study of implementation of reduced ADS-C reporting intervals. Such evaluations would be based on specific operational concepts, projected traffic and messaging profiles, and proven evaluation methodologies that include properly bounded, realistic, operational targets defined as “scenarios”.

6.50 The Meeting was presented with results of a short duration trial conducted by New Zealand using ADS-C periodic intervals of 64 seconds and 3 minutes with up to 6 aircraft over a 4 day period. The trial used two ATC ground systems to establish 64” and 3 minute interval periodic contracts with aircraft over extended periods. The Meeting was provided with RSP 180 performance data on aircraft with 64 seconds and 3 minute periodic interval contracts with 2 ATC ground systems that demonstrated the performance meeting RSP180 specification (WP02 refers). No system degradation was noted on the Airways New Zealand ATM platforms during the trials. Some software development was identified as required and planned for implementation to better handle the large profiles created with aircraft operating 64” interval for long periods.

6.51 The Meeting noted the trial conclusions about the ability of some aircraft and ground systems to operate with 64 seconds and 3 minutes periodic intervals to selectively support the proposed reduced separation minimum when published by ICAO.

6.52 In following discussions, the Meeting noted that currently some ATC systems were using 64 second periodic interval when aircraft were in emergency and some ground systems were reported using 64 second periodic interval in standard operations in limited areas. There were no performance degradation or other issues reported associated with these implementations. In this connection, the Meeting noted that technically the existing communications system was designed to be capable to cope with all ADS-C periodic reporting intervals down to the minimum stated in the FANS 1/A standards as 64 seconds. However, it was noted that there was no performance data available for the maximum number of contracts at a 64 second interval to validate that this use was feasible.

6.53 The Meeting also noted that while the application allows at least 4 connections (+1 AOC connection), the ADS-C RITF cannot envisage a need for all connections simultaneously supporting the periodic reporting interval requirements for reduced longitudinal separation minima.

6.54 The communications system performance was continuously monitored to match the actual usage in order to balance the system capacity accordingly per system loads in different regions. Through this monitoring, if a need is determined to increase the system capacity, the SSPs and CSPs must undertake necessary measures to increase the channels capacity, increase the number of frequencies required, and increase the GES processing power. In order to plan for such measures, coordination with the implementers of reduced separation minima requiring reduced ADS-C reporting intervals would be essential.

6.55 To that end, in order to help implementers to manage the process of implementing reduced reporting intervals in support of reduced longitudinal separation minima, the RITF recommended that appropriate guidance material be provided either in ICAO GOLD Manual (Doc 10037) or a Circular providing implementation guidance for reduced separation minima.

6.56 In conclusion, the Meeting agreed that the following responses to tasking from the NAT SPG and APANPIRG could be provided:

a) What can the systems support without degradation? 64 seconds?

- The system can achieve 64 seconds on a limited scale, such as for emergency reporting (abnormal/distress tracking needs). It is being used today, when initiated by the flight crew, as a 64 second emergency mode report, and, on occasion, ANSP ground systems are setting 64 second periodic contracts. ICAO GOLD Manual (Doc 10037) provides guidance on the selection of reporting intervals in Section 3.5.4.

- On a larger scale, it is not possible to answer this question without assessing the ANSP and AOC concept of operation. Specifics about operations, separation minima, reporting intervals, messaging traffic and traffic growth must be understood as part of this analysis.

b) What is needed to reduce ADS-C reporting intervals to support reduced performance based longitudinal separation?

- An ICAO endorsed methodology should be followed to establish the system performance requirements for performance based reduced separation minima.

6.57 In response to the ToRs, the following conclusions were made:

c) Better understand the sensitivities to system loading based on ADS-C reporting intervals:

- The key sensitivities are:

i. for SATCOM, how each channel is utilised and loaded in the global beam;

ii. for VHF, RF channel capacity for plain old ACARS stations located in oceanic transition areas;

iii. For ANSP, the impact of the increased reporting rates on system design;

iv. For airspace users and aircraft manufacturers, the impact on avionics.

d) Determine a minimum ADS-C periodic reporting interval that would be technically feasible under specified conditions without significantly impacting operational performance;

- The answer is dependent on the concepts of operation at regional, ANSP and AOC levels. Based upon the concepts discussed by the ADS-CRITF, provided ICAO Doc 10037 and ICAO Circular XXX includes requirements and guidance for ANSPs, regional groups, and airlines on planning, coordinating and implementing new operational concepts and requirements for reduced separation standards and higher periodic reporting rates, then:

i) For the current Classic/VHF datalink system:

– Tree minutes are feasible, if needed, to support a new separation standard at RSP 180, with an understanding that, based upon the ANSP and AOC operational concepts or requirements: if widely used, financial impacts may be incurred to support additional system capacity;

– 64 second is feasible on an exception basis for abnormal/distress reporting: if used more widely, financial impacts may be incurred to support additional system capacity.

ii) For the SwiftBroadband-Safety (SB-S) system over oceanic and remote airspace:

– Two minutes are feasible to support a new separation standard at RSP 180, with an understanding that, based upon the ANSP and AOC operational concepts or requirements: if widely used, financial impacts may be incurred to support additional system capacity;

– 64 second is feasible on an exception basis for abnormal/distress reporting: if used more widely, financial impacts may be incurred to support additional system capacity.

iii) i) above is based on experience of operation of current systems. ii) is an assessment of the evolving future system supported by expanding on the experience of a), theory, and data from on-going evaluations. The effect of reporting intervals below 2 minutes on avionics performance needs to be assessed.

e) Determine benefit to the regions in their planning and implementation of future ATM concepts of operation (e.g., NAT Service Development Roadmap and future 2025 concept of operations).

- New SATCOM systems provide new methods for providing position reporting that do not employ ADS-C. These position reports can be streamed at high rates to ground systems. Some of these systems are planned for deployment in the near term.

f) Support validation of future standards for applying minimum separation based on ADS-C, such as 37 km (20NM) longitudinal separation minimum, currently under development by the Separation and Airspace Safety Panel (SASP).

- See 6.56 b) above

6.58 Finally, the Meeting agreed the following future actions by the ADS-C RITF:

a) Provide this meeting report as an interim ADS-C RITF report to NAT SPG/52 and APANPIRG in 2016;

b) Develop draft amendments to Doc 10037 by September 2016 for consideration by the NAT Technology and Interoperability Group (TIG) and OPDLWG;

c) Provide a final report to APANPIRG in September 2017 and NAT SPG/53 in June 2017;

d) Provide input material to the ICAO SASP in September 2016;

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