International Civil Aviation Organization

ICAO

Twenty Fifth Meeting of the Communications/ Navigation and Surveillance Sub-group (CNS SG/25) of APANPIRG

Video Tele-Conference, 18 – 22 October 2021

Agenda Item 6: Surveillance

6.1 Review Report of Sixth Meeting of the Surveillance Implementation Coordination Group (SURICG/6) including:

- Report of the First Meeting of the Surveillance Study Group (SURSG/1);
- Report of the Fourth Meeting of Mode S Downlinked Aircraft Parameters Working Group (Mode S DAPs WG/4);

REVIEW REPORT OF SIXTH MEETING OF THE SURVEILLANCE IMPLEMENTATION COORDINATION GROUP (SURICG/6)

(Presented by the Secretariat)

SUMMARY

This paper presents the report of the Sixth Meeting of the Surveillance Implementation Coordination Group (SURICG/6), including reports of Fourth Meeting of Mode S Downlinked Aircraft Parameters Working Group (Mode S DAPs WG/4) and First Meeting of the Surveillance Study Group (SURSG/1), for review and action.

1. INTRODUCTION

1.1 The Sixth Meeting of the Surveillance Implementation Coordination Group (SURICG/6) was held from 24 to 27 August 2021 via video teleconference. The meeting was attended by 116 participants from 19 States/Administrations, 4 International Organizations, 1 aircraft manufacturer, and 1 service provider from industry (IATA, ICCAIA (Aireon), IFATCA, RTCA, Boeing and PCCW Global).

1.2 The SURICG/6 meeting considered 13 working papers, 23 information papers, 1 presentation and 1 flimsy and adopted seven (7) Draft Conclusions and two (2) Draft Decisions for consideration and endorsement in CNS SG/25 meeting. The meeting report, working papers, information papers and other resources can be accessed at https://www.icao.int/APAC/Meetings/Pages/2021-SURICG-6.aspx.

1.3 The SURICG/6 meeting reviewed the report of the Fourth Meeting of Mode S Downlinked Aircraft Parameters Working Group (DAPs WG/4) which was held from 29 to 31 March 2021 via video Tele-conference. The DAPS WG/4 meeting was attended by 99 participants from 18 States/Administration and 3 International Organizations (EUROCONTROL, IATA and IFATCA). The DAPs WG/4 meeting report, working papers, information papers, and other resources can be accessed at https://www.icao.int/APAC/Meetings/Pages/2021-DAPs-WG4.aspx.

1.4 The SURICG/6 meeting also reviewed the report of the First Meeting of the Surveillance Study Group (SURSG/1) which was held from 20 to 22 April 2021 held via video tele-conference. The meeting was attended by 118 participants from 15 States/Administration and 4 International Organizations and 2 industry partners (CANSO, IATA, ICCAIA, IFATCA, Frequentis and PCCW Global). The SURSG/1 meeting report, working papers, information papers, and other resources can be accessed at https://www.icao.int/APAC/Meetings/Pages/2021-SURSG-1.aspx.

1.5 This paper summarized relevant information and updates from the meeting.

2. DISCUSSION

2.1. The summary of discussion in the meeting is given in following paragraphs.

Outcome of Relevant Meetings on Surveillance (WP/02) - Secretariat

2.2. The meeting reviewed relevant information and updates on Surveillance arising from SURICG/5, CNS SG/24 an APANPIRG/31.

Review Report of Mode S DAPs WG/4 (WP/03) - Secretariat

2.3. The SURICG/6 meeting reviewed the proposal to amend formerly adopted APANPIRG Conclusions related to II codes and extend the consideration to the use of SI codes. After discussion, the following Draft Conclusion was adopted for consideration in CNS SG/25:-

<table>
<tr><td colspan="2">Draft Conclusion CNS SG/25/XX (SURICG/6/1) (Draft Conclusion DAPs WG/4/1, Draft Conclusion DAPs WG/4/2, Draft Conclusion DAPs WG/4/3) - Interrogator Code (IC) Planning and Coordination</td></tr>
<tr><td>What: That,

With the need to extend the Use of Surveillance Identifier (SI) in Interrogator Code (IC) on top of Interrogator Identifier (II), the relevant APANPIRG Conclusions are updated as follows:-

Coordination Process for SSR Mode S Interrogator Code (IC)
(formerly Conclusion 19/40)

a) in view of the increasing density of SSR interrogator installations in the region, and that States have varying readiness to extend from Interrogator Identifier (II) to both Interrogator Identifier and Surveillance Identifiers (SI) codes, there will be a period whereby both II and SI will be used.

b) while implementing SSR Mode S, States should take into account following issues while assigning IC for these installations:</td><td>Expected impact:
☐ Political / Global
☒ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
</table>

<table>
<tr><td colspan="2">

for planning the implementation of SSR Mode S interrogators, administrations should ensure that the interrogators with overlapping coverage are not operating with the same IC.
where, the coverage of the interrogator extends beyond the boundaries of the State, The IC should be worked out in coordination with the ICAO Asia and Pacific Office and the neighboring States concerned, and
administrations should inform the ICAO Asia and Pacific Office about the assigned IC for these installations.

Coordination Requirements for SSR Mode S Interrogator Codes (IC) (formerly Conclusion 20/56)
States be advised to provide the following information on SSR Mode S Interrogator Code to the ICAO Asia/Pacific Office for coordination and registration.
a) Name of country/territory and location of facility;
b) Antenna Coordinates (Latitude and Longitude);
c) Elevation of antenna above the Mean Sea Level (MSL) in meters;
d) Maximum Coverage of SSR Mode S Interrogator in nautical mile;
e) II Code (1 to 15) or SI Code (1 to 63); and
f) Remarks (special configuration such as radar clustering, lockout override, II/SI mode capability)
Planning Criteria for SSR Mode S Interrogator Code (IC) Assignment (formerly Conclusion 20/57)
The planning criteria for SSR Mode S IC coordination and assignment as provided in Appendix J of Doc 9924 (Third Edition, 2020) be adopted for use in the Asia/Pacific Region.
</td><td></td></tr>
<tr><td colspan="2">
Why: Due to higher density of radars, some States are facing a shortage of II codes. It has to be solved by transiting from II to SI code. It is noted that state may use a mixture of II and SI codes before complete migration to SI code.
The assignment of interrogator codes (IC), where necessary in areas of overlapping coverage, across international boundaries of flight information regions, shall be the subject of regional air navigation agreements.
States still have to coordinate with ICAO APAC Regional Office on the allocation of II codes and SI codes.
</td><td>Follow-up:
☒Required from States</td></tr>
<tr><td>When: 02-Dec-2021</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: SURICG</td></tr>
</table>

Note: This draft conclusion will supersede ***APANPIRG Conclusions 19/40, 20/56 and 20/57*** *once adopted.*

2.4. In association, the *Table for SSR Mode S Interrogator Code Coordination* was reviewed as provided in the template in **Appendix A** to this paper. It was reported that Chairpersons of DAPs WG and the ICAO secretariat approached the Surveillance Panel about the addition of SI code allocation criteria into Doc 9924, and DAPs WG will work to reflect the required updates in Mode S DAPs IGD.

2.5. The SURICG/6 meeting reviewed the strategy of transition from II code to II and SI mixed code and the following Draft Conclusion was adopted by the meeting for consideration in CNS SG/25:-

<table>
<tr><td colspan="3">Draft Conclusion CNS SG/25/XX (SURICG/6/2) (DAPs WG/4/4) - Transition from II code to II and SI mixed code</td></tr>
<tr><td colspan="2">What: States with Mode S radar capable of performing II/SI mode operations are encouraged to transit from II code to II and SI mixed code, so as to ease the shortage of II codes. States planning to perform the transition shall coordinate with ICAO APAC Regional Office to obtain the SI codes.</td><td>Expected impact:
☐ Political / Global
☐ Inter-regional
☒ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: Due to higher density of radars, some States are facing a shortage of IC codes, which has to be solved by transiting from II to II and SI mixed code. It is noted that radars using II and SI codes can co-exist, hence there is no need for a big bang approach. However, States still have to coordinate with ICAO APAC Regional Office on the allocation of SI codes.</td><td colspan="2">Follow-up: ☐Required from States</td></tr>
<tr><td>When: 02-Dec-2021</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: SURICG</td></tr>
</table>

2.6. The DAPs WG/4 revised the proposed Regional Roadmap for Mode S Implementation by the DAPs WG/3, which covered the topics including Mode S mandates, use of SI Codes, radar clustering, use of conspicuity code, mandating weather reporting capability, datalink map and monitoring of 1030 and 1090 MHz usage. The SURICG/6 meeting reviewed the revised Regional Roadmap provided in **Appendix B** to this paper and the following Draft Conclusion was adopted for the consideration of CNS SG/25:

<table>
<tr><td colspan="3">Draft Conclusion CNS SG/25/XX (SURICG/6/3) (DAPs WG/4/5) - The APAC Regional Roadmap for Mode S Implementation</td></tr>
<tr><td colspan="2">What: That, the APAC Regional Roadmap for Mode S Implementation provided in Appendix B to this paper be adopted.</td><td>Expected impact:
☐ Political / Global
☐ Inter-regional
☒ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: The revised Roadmap defined the scope and rational steps for the implementation of Mode S in APAC region.</td><td colspan="2">Follow-up: ☐Required from States</td></tr>
<tr><td>When: 02-Dec-2021</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: SURICG</td></tr>
</table>

2.7. A proposal for revised draft Edition 3.0 of the Mode S DAPs Implementation and Operations Guidance Document (IGD) was discussed in SURICG/6 which was provided in **Appendix C** to this paper. The main amendments include advice to mandating Mode S transponder, other protocols for DAPs extraction, use of parameters in the ATM automation system, Mode S DAPs application examples and identified issues, and Mode S radar parameter information. SURICG/6 adopted the following Draft Conclusion for the consideration of CNS SG/25 meeting:

Draft Conclusion CNS SG/25/XX *(SURICG/6/4) (DAPs WG/4/6)* - Mode S DAPs IGD 3.0	
What: That, the *Mode S DAPs Implementation and Operation Guidance Document* Edition 3.0 provided in **Appendix C** to this paper be adopted.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: Editorial correction and revision to reflect regional updates in implementation.	Follow-up: ☐Required from States
When: 22-Oct-2021	Status: Draft to be adopted by Sub-Group
Who: ☐Sub groups ☐APAC States ☐ICAO APAC RO ☐ICAO HQ ☒Other: SURICG	

2.8. EUROCONTROL published the System Area Codes (SAC) for the various regions except for Asia Pacific. The DAPs WG/4 meeting discussed the considerations to publish the Asia Pacific SAC at the EUROCONTROL website. ICAO APAC also keeps track of the SIC allocation within the States through the Regional Supplement to ASTERIX Interface Control Document which States have their own control over the use of SIC and may change overtime without the need for ICAO APAC to manage. Subsequently the Regional Supplement to ASTERIX Interface Control Document provided at **Appendix D** to this paper was reviewed and the following Draft Conclusion was endorsed by the SURICG/6 meeting for consideration of CNS SG/25:

Draft Conclusion CNS SG/25/XX *(SURICG/6/5) (Draft Conclusion DAPs WG/4/7 and Draft Decision DAPs WG/4/8)* - Revision of the Regional Supplement to ASTERIX Interface Control Document (ICD)	
What: ICAO APAC Regional Office to:- a) update EUROCONTROL with the latest SAC allocation within Asia Pacific; and b) to coordinate the allocation of SAC within Asia Pacific and not the SIC.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: a) EUROCONTROL published the SAC for all the regions except Asia Pacific. It is believed that the publication will be beneficial to the developers of future message protocol and surveillance related applications. b) SIC is managed by State and there is little value for ICAO APAC to manage the SIC. Considering the workload to manage the SIC and the negligible benefits, it is proposed that ICAO APAC not to manage SIC.	Follow-up: ☐Required from States
When: 22-Oct-2021	Status: Draft to be adopted by Sub-Group
Who: ☐Sub groups ☐APAC States ☐ICAO APAC RO ☐ICAO HQ ☒Other: SURICG	

Report on Survey on Current use and Future planning of Mode S Enhanced Surveillance (EHS) Implementation (WP/08) - Secretariat

2.9. The Mode S DAPs WG/4 resulted into an Action Item on conducting a *Survey on Current use and Future planning of Mode S Enhanced Surveillance (EHS) Implementation* to the Member States. Additionally, a separate questionnaire were sent to IATA to respond to the question related to

ELS Mode S capability and EHS Mode S capability of commercial fleets in APAC region. ICAO APAC Office received response from twelve (12) Member States with the graphical representations of responses received from States and IATA were provided in an appendix to that paper. The outcomes of the survey conclude that most States are not facing any challenges in implementing APANPIRG/31/14 Conclusion. Additionally, the commercial fleet in APAC, North America, and MENA are already possess Mode S ELS and EHS Mode S capability. IATA expressed gratitude to ICAO Secretariat for the survey outcomes presentation and informed that they are satisfied by the outcomes. EHS provides additional information, such as track angles, to ATM Automation Systems for better situation awareness for ATC.

Status on the Updates to the Mode S SI/II Codes Assignment Criteria in Doc 9924 (IP/02) - China, Japan, Singapore and Secretariat

2.10. As Doc 9924, Aeronautical Surveillance Manual does not contain sufficient information to help APAC region to plan the implementation of II and SI mixed code environment, a small working party comprising of representatives from China, Japan, Singapore, and ICAO Secretariat were formed in DAPs WG/4 to amend the Doc 9924 to provide necessary guidance material. A proposal was submitted to the Surveillance Panel- Aeronautical Surveillance Working Group (SP-ASWG) to initiate the review of the Doc 9924 on the portion of II and SI code allocation. Subsequently, the working party generated two papers to Aeronautical Surveillance Working Group-Technical Subgroup (ASWG-TSG), which address the elements to be considered when introducing SI code assignments in the APAC Region, considering that during the transition phase not all aircraft may be equipped with SI capable transponders. ASWG-TSG agreed to include the technical material presented in these papers and it will be reviewed in next ASWG-TSG meeting in first quarter 2022. Furthermore, the paper proposed that the DAPs WG continue work on this matter in parallel with the Surveillance Panel, based on the relevant material in Doc 9924 with the view to improve current guidance in the Appendices H and J of Doc 9924. The results from DAPs WG may be presented to the Surveillance Panel (SP) as draft updates to Doc 9924.

Updates on Mode S Interrogator Identifier (II) codes coordination in the APAC Region (IP/13) – Secretariat

2.11. The paper provided the latest updates about Mode S II codes coordination in the APAC Region including a request from Eurocontrol for few new Mode S radars whose coverage overlaps several States in APAC, and another request for assignment of II Codes to 10+ planned Mode S Radars in a State near MID region and EUR region in the year 2021. In addition, an ongoing discussions on allocation of II codes 14 and 15 with matching SI codes were shared. The meeting was informed that in CNS SG/24 conflicting II codes were identified in neighbouring States concerned, therefore States were encouraged to provide updates and coordination with ICAO APAC Regional Office for updating the SSR II code list through appropriate focal point, to eliminate any potential operational risk due to duplicated II code implementation in overlapped coverage at boundary area. The meeting noted that in future, when SI codes will be considered to be deployed in APAC Region, the coordination will be more complicated. Therefore, Doc 9924 will be further enhanced to cater for the needs and the meeting will continue to invite Surveillance Panel members to brief the Region on the matter.

Review Report of the First Meeting of the Surveillance Study Group (SURSG/1) (WP/04) - Secretariat

2.12. This paper summarized relevant information and updates with the highlight on the reviewed outcomes of SURSG/1 was held from *20 to 22 April 2021* held via video tele-conference.

2.13. Based on the recommendation of SURSG/1, SURICG/6 reviewed the revised ToR of SURSG as provided in **Appendix E** to this paper and adopted the following Draft Decision for the consideration of CNS SG/25:

<table>
<tr><td colspan="3">Draft Decision CNS SG/25/XX (SURICG/6/6): Revised ToR of Surveillance Study Group (SURSG)</td></tr>
<tr><td colspan="2">That, the Revised Terms of Reference of the Surveillance Study Group (SURSG) provided in Appendix E to this paper be adopted.</td><td>Expected impact:
☐ Political /Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: The SURSG/1 meeting reviewed the ToR and made amendments on adding chair role and function, frequency of the meeting of SURSG and the mode of the various task lead meetings for effective progress update, decision making, work assignments as they arise and the need to update the list of contributing States as necessary.</td><td colspan="2">Follow-up: ☐Required from States</td></tr>
<tr><td>When: 22-Oct-2021</td><td colspan="2">Status: Draft to be adopted by Sub-Group</td></tr>
<tr><td colspan="3">Who:☒Sub groups ☐ APAC States ☐ICAO APAC RO ☐ICAO HQ ☐APANPIRG ☐ Other:</td></tr>
</table>

2.14. The meeting discussed that as per ToR, SURSG shall complete four deliverables within its term. For each of the deliverables, a list of sub-tasks were identified for elaborating its required work content and facilitate the work sharing by Member States. The agreed work plan with focal point of voluntary Administrations/Organization was provided in an appendix to that paper.

Proof-of-concept for Surveillance data sharing on SWIM by Surveillance Study Group (SURSG) (WP/12) - Hong Kong, China on behalf of SURSG

2.15. Hong Kong, China proposed a proof-of-concept (POC) for surveillance data sharing on SWIM to be conducted in Hong Kong China. The meeting was informed the tasks for the study group were grouped under two stages, namely feasibility study stage and recommendation stage. In parallel with the feasibility study, Hong Kong China plans to have a POC conducted by sharing ADS-B data collected in Hong Kong on a simulated SWIM EMS over CRV based on a hybrid infrastructure model, which is a mix of “Distributed Model” with ANSPs operating their own EMS and the “Centralized Model” with ANSPs accessing centralized SWIM services. The POC was explained by a high-level system block diagram in the paper. The meeting expressed support to the POC and on-going work of the SURCG. Hong Kong China is working with the CRV provider, PCCW Global, on a POC demonstration, which is planned to take place in 2022.

Proposed Concept of Operations for Surveillance Data Sharing (IP/17) – Singapore, Hong Kong China, Thailand, and Viet Nam

2.16. As the outcome of Sub-task 2.1 of SURSG work plan, the paper described the proposed Concept of Operations (CONOPS) for sharing of surveillance data among multiple parties using platform such as SWIM along with the objective of the CONOPS, so as to solicit suggestions/concerns from SURICG for consideration by SURSG in formulating the CONOPS. The paper explained the high level objectives and understanding of the surveillance data sharing, including two tiers of data services based on the criticalness of ATS applications to be supported, two options of extent of data sharing, and three models of implementation platform namely distributed, centralized and hybrid models. Furthermore, types of surveillance data to be shared and its implementation sequence were elaborated. Additionally, consideration of 3rd party/commercial participation and various choices of data coverage along with responsibilities of data contributors for system availability, data integrity, report filtering, data timeliness and latency, update interval, data formats, the rights and responsibilities of users and data consumers, including safety-related ones, user obligation, options for receiving shared data, and other considerations were discussed. Finally the trial case by pioneering members were explained with consideration of financial and other essential governance principles.

Review of Regional Requirements for Surveillance in APAC e-ANP and Seamless ANS Plan (WP/05) – Secretariat

2.17. ICAO Secretariat reviewed the origins of APANPIRG Conclusions and consolidated the Regional surveillance requirements specified in the Regional e-ANP and the Seamless ANS Plan (Version 3.0, November 2019) in this paper. The meeting noted that the next review year for the Asia/Pacific Seamless ANS Plan is scheduled for 2022. The meeting was informed about the coverage map of surveillance and DCPC included in the Seamless ANS Plan was expected to be updated through joint effort before the next Seamless ANS Plan review .

Update on Regional Supplement to ASTERIX Interface Control Document (ICD) for ASIA/PAC Region (WP/06) – Secretariat

2.18. ICAO Secretariat presented the recent updates to the Regional Supplement to ASTERIX ICD for ASIA/PAC Region ("the Supplement") and introduced the planning criteria and current usage of SAC in APAC region. The meeting was informed that with the actual or planned increase in number of sensors/systems going over 256 distinct SICs allocable to assigned SAC for a State/Administration/Territories, it might need to apply for additional SAC(s) to cater the need to identify distinctly of its sensors/systems. Meeting noted that current allotments would be enough to cater the actual and planned increase of surveillance sensors and automation systems in the APAC Region. The meeting agreed to use surveillance and automation systems in the Supplement at the place of "radars". ICAO Secretariat proposed changes in wordings which was reviewed and endorsed in the meeting as Appendix E to the meeting report in tracked change mode.

The SAC SIC Code Allocation Management and Planning in China (IP/22) – China

2.19. China introduced the allocation management and future planning of SAC and SIC codes in China due to their forward planning from the construction plan for ATMB of CAAC during the 14th Five Year Plan period (2020-2025) and the professional plan of CNS for the next ten years (2020-2030). The meeting was informed that due to the forward planning, China had applied to ICAO APAC Office for the allocation of additional SACs and ICAO APAC Office has assigned accordingly after review.

Stocktake on Documents to Update under Agenda Item 6 (WP/13) – Secretariat

2.20. This paper introduced the background of the four documents to be reviewed under the Agenda Item 6 on *review implementation and co-ordination activities and sub-regional implementation plans* per the consolidation of supporting bodies under SURICG, which these documents were discussed and reviewed for the implementation and coordination activities and sub-regional implementation plans with focus on ADS-B. *ADS-B Implementation Status in the APAC Region,* which depicted the overall implementation status in APAC, is provided in the **Appendix F** to this paper for review in CNS SG/25. The other documents reviewed in the meeting were *ADS-B Data Sharing Implementation Status in the APAC Region* (Appendix I to the Report of SURICG/6 refers) and Reports on the Sub-regional ADS-B Implementation Plan/Projects presented by South East Asia (SEA) and Bay of Bengal (BOB) Ad Hoc Working Groups (Appendix F and G to the Report of SURICG/6 refers). During the discussion in Ad Hoc Working Groups, some States had shared to the meeting that with the implementation of space-based ADS-B, the original ground-based ADS-B data sharing project would have to be re-evaluated.

Inconsistent ICAO Aircraft Address and Target identification Between ADS-B Data and Flight Plan (WP/11) - Hong Kong China

2.21. Hong Kong China presented the observation on recurring inconsistencies of ICAO Aircraft Address and Target Identification between ADS-B data and flight plan for some aircraft flying within Hong Kong Flight Information Region. Hong Kong China expressed such issues has not only caused safety implications to ATC operation but also induced additional workload to both air traffic controllers and to supporting staff for following up with the concerned airlines proactively. As such, the paper proposed the following Draft Conclusion which was endorsed in SURICG/6 for further consideration of CNS SG/25:

Draft Conclusion CNS SG/25/XX (SURICG/6/7) - Integrity of ICAO Aircraft Address and Target Identification in ADS-B / MLAT / Mode S Data and Flight Plan	
What: To urge States/Administrations to proactively follow up with air operators to address discrepancies of ICAO Aircraft Address and Target Identification between ADS-B / MLAT / Mode S data and flight plan.	Expected impact: ☐ Political / Global ☐ Inter-regional ☐ Economic ☐ Environmental ☒ Ops/Technical
Why: Such discrepancies will cause safety implications in ATC operation and induce additional workload to controllers and supporting staff in handling the cases.	Follow-up: ☒Required from States
When: 22-Oct-2021	Status: Draft to be adopted by Sub-group
Who: ☒Sub groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐Other:	

2.22. USA appreciated Hong Kong, China for the paper and informed that FAA has been working with airlines in the United States to resolve such issues. USA invited Hong Kong China to share the details of observations related to airlines of USA. In addition, IATA expressed their willingness to promulgate the human issues reported in the paper to its member airlines and to work with Hong Kong China to follow up on the issues.

Practical approach to access the performance of surveillance systems (IP/04) – Republic of Korea (ROK)

2.23. ROK presented the common misunderstanding about the radar specification and suggested the practical approach to access the performance of surveillance systems. ROK informed that current surveillance performance specifications contained the requirements mentioned in Eurocontrol Standard Document for Radar Surveillance "SUR.ET1.ST01.1000-STD-01-01", which is quite old and could not include the recent innovation of surveillance technology. The paper tabulated the common misunderstanding about PSR & MSSR performance specifications with explanation and suggested the practical approach in a list of radar performance specification. The paper also introduced the practical examples on real time monitoring on the PSR & MSSR performance on using software tools. Lastly, the paper invited ANSPs to share their benchmark and performance test through ICAO workgroups as decision criteria for comparing future surveillance systems projects and to find the best optimum surveillance system for their country and airport.

2.24. In view of the matter arising from the paper, the meeting discussed and suggested to form an Ad-hoc working group to discuss performance specifications and benchmarking of radar for APAC Region, and to prepare a working paper to make recommendation on the way forward to SURICG/7. China, India, Indonesia, Republic of Korea and Singapore volunteered to join the group.

Performance-based Operations Aviation Rulemaking Committee (PARC) Action Team (AT) Exemption 12555 Report (IP/06) – USA

2.25. FAA presented the report by the Performance-based Operations Aviation Rulemaking Committee (PARC) to the FAA that contained an assessment of how well operators (exemption holders) will be able to achieve planned position source upgrades prior to the expiration of Exemption No. 12555 by December 31, 2024. The meeting was informed that the Exemption was published in 2015 to permit exempted operators to continue using Global Positioning System (GPS) position sources that may not always meet the integrity and accuracy requirements of FAA and One of the conditions of the Exemptions was that each operator must create, maintain, and update a GPS position source equipage plan for aircraft equipped for ADS-B Out. It was explained that the report included assessments to different factors related to the exemption and certain recommendations made by the Action Team, which has been submitted to FAA for their review and evaluation.

Recent ADS-B Avionics Issues Observed in the USA (IP/07)

2.26. FAA provided a description of two ADS-B avionics issues observed in the USA with DO-260B/ED-102A systems, namely Embraer 17x track jumping and Honeywell Primus II RCZ. FAA informed that it monitors all ADS-B Version 2 information received in all airspace covered by FAA-contracted ADS-B ground stations via a tool called the ADS-B Performance Monitor (APM). Details of issues and actions taken by FAA were provided in the paper. The meeting agreed to incorporate these issues in the paper into AIGD for easy reference in this region.

ADS-B Equipage and Quality Performance in USA (IP/14)

2.27. FAA provided a summary of observed NIC/NACp performance compared to the requirements of the USA ADS B mandate, as well as ADS-B equipage trends in the USA. The paper demonstrated how the performance benchmarking from airlines fleet were performed. FAA added that FAA's ADS-B Performance Monitor (APM) has capabilities for tracking ADS-B equipage trends, including ADS-B versions and the link type of aircraft (1090ES, UAT or DUAL).

Diagnosis and Maintenance about a SSR Target Deviation Fault (IP/18) – China

2.28. China introduced a case on the diagnosis and maintenance of a fault of a Mode S SSR, in which the detected aircraft position deviated from true position since 30 October 2020. With data analysis and fault diagnosis over 3 months, it was concluded the symptoms were caused by the poor horizontal stability of the mechanical transmission component inside the antenna pedestal. Details of the analysis, troubleshooting and recommendation on maintenance of SSR radars were described in the paper.

Status of Space-based ADS-B (IP/09) –Aireon/ICCAIA

2.29. Aireon presented status of space based ADS-B as a service which has been operational for some time in various ANSPs. The meeting was informed that EASA has certified Aireon as an ANSP for the provision of operational surveillance data and the Doc 4444 has been updated to allow reduced oceanic separation using Space based ADS-B with CPDLC and some ANSPs is performing tests on the reduced oceanic separation. Aireon informed that Space based ADS-B has the potential to complete the coverage picture even in States that have significant ground based radar or terrestrial ADS-B. Meeting noted that space based ADS-B data was provided into APAC CRV network since 2020 and it is currently supporting Papua New Guinea (PNG) ATC operations. An example from NiuSky Pacific was explained to illustrate the benefits.

Report on the ADS-B In Retrofit Spacing (AIRS) Evaluation Project (IP/08) – USA

2.30. FAA presented the ADS-B In Retrofit Spacing (AIRS) evaluation project, a large-scale operational evaluation of two ADS-B In applications, namely Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS) and Interval Management (IM) since September 2017. The project aimed to promote early adoption of ADS-B In applications. Details of equipage and trials were explained in the paper. Besides, FAA and AAL are also planning to conduct an operational trial using CAVS avionics functionality in ceiling and visibility conditions that would not currently qualify for "pilot-applied visual separation" in the USA, which is referred as "CDTI-Assisted Separation" (CAS). The meeting was informed that FAA was involved in developing the Doc 9994, the Manual on Airborne Surveillance Applications, as well as development of guidance on the ADS-B capabilities including Interval Management (IM) to be considered for incorporation to PANS for harmonized implementation.

A Non-Cooperative Method for DAPs Data Recognition (IP/19) – China

2.31. China introduced a non-cooperative DAPs data recognition and determination method which could be used for DAPs data interception and extraction to avoid BDS swap phenomenon described in DAPs IGD and presented Mode S DAPs WG/4 meeting. The logic is based on the different data structures of ELS and EHS which by comparing particular bits in BDS information, it could be verified that the piece of information should belong to which exact BDS and not others, thus pointing to the correct BDS and prevented / reduced BDS swap. Such method also makes it possible for third-party monitoring equipment to correctly decode the DAPs data. Further work could be done on analyzing the relationship between the DAPs according to the performance of the jet transport aircraft, and trials to use the relationship between the parameters to determine the BDS type.

ICAO Surveillance Panel Activities (IP/11)

2.32. This paper updated the SURICG/6 meeting about the information and discussions from the most recent meetings of the SP-ASWG/13 and the SP-AIRBWG/11, both held in April 2021. SP-ASWG/13 considered a Proposal for Amendment (PfA) to Annex 10 Volume III for Allocation of additional 24-bit Aircraft Addresses for of all States that currently are allocated 1024 addresses, for which the proposal to be presented to the Communications Panel (CP) and Data Communications Infrastructure Working Group (DCIWG) for their comments. The feedback on this PfA is hoped to be processed in Fourth Meeting of Surveillance Panel (SP/4) in spring 2022. SP-ASWG/13 also discussed the plans for creating a consequential Change Proposal to Doc 9871, "Technical Provisions for Mode S Services and Extended Squitter.", and the 1030/1090 MHz congestion mitigation methods and data from various 1030/1090 MHz measurement campaigns in various ICAO States around the world. The planned SP Working Group meetings in 2022 and 2023 are listed and it was added that SP/5 will consider several PfAs to Annex 10 Volume IV to align SARPs with the latest EUROCAE/RTCA avionics standards for Mode S transponders with Extended Squitter (ADS-B Version 3), ADS-B IN systems with applications including IM, and additional variants of ACAS X.

RTCA Standards Supporting Global Interoperability (IP/23)

2.33. RTCA informed that a Combined Surveillance Committee (CSC), which made up of RTCA and EUROCAE committees working on ADS-B and Mode-S technologies, was created in January 2016. In December 2020, CSC jointly published three documents relating to surveillance technology namely DO-260C/ED-102B (ADS-B), DO-361A Change 1/ED-236A Change 1 (Flight-deck Interval Management (FIM) Change 1), DO-181F/ED-73F Mode-S Transponder. It was informed that RTCA and EUROCAE are beginning to work on the development of DO-260C/ED-102B Change 1 and DO-181F/ED-73F Change 1 with expected publication in December 2021 to address and correct issues that have been identified since the publishing of the original documents. RTCA has undertaken an update of DO-282B Minimum Operational Performance Standards (MOPS) for Universal Access Transceiver (UAT) and ADS-B, which includes changes necessary to align the document and requirements therein with changes that are already incorporated into DO-260C. There will also be a review and correction of issues that have been identified since the publishing of UAT ADS-B MOPS

(DO-282B).

ADS-B - A Boeing Perspective (SP/01)

2.34. Boeing introduced their ADS-B Out implementation roadmap on their various aircraft models and informed that their fleets were planned well ahead for the European and United States ADS-B DO-260B Out mandates. The ADS-B Out System certification technical requirements and different ATC transponder and ISS processors unit capabilities on each model were explained. In addition, the development of ADS-B In solutions for Boeing fleet were defined and it was informed that Boeing conducted forward-fit studies targeting primary field-of-view to ensure cost-effective architectures with growth capability. The presentation introduced several applications including Airborne (AIRB) – Cockpit Display of Traffic Information (CDTI), Visual Separation on Approach (VSA) and In Trail Procedure (ITP). Boeing informed that it worked with ANSPs to ensure common airborne requirements and global harmonization and continued the support to ADS-B industry standards (RTCA/EUROCAE/AEEC). The meeting was further informed that the fitment for DO-260C was not shown on the timeline as it is still being finalized.

Review SURICG ToR with integration of SEA/BOB ADS-B WG ToR (WP/10) - Secretariat

2.35. SURICG ToR was reviewed in the meeting in the view of integration of SEA/BOB ADS-B WG ToR. As the result of review, the SURICG ToR was found necessary to be updated as provided in **Appendix G** to this paper and the following Draft Decision was adopted for consideration in CNS SG/25:

<table>
<tr><td colspan="3">Draft Decision CNS SG/25/XX (SURICG/6/8): Revised ToR of Surveillance Implementation Coordination Group (SURICG)</td></tr>
<tr><td colspan="2">That, the Revised Terms of Reference of the Surveillance Implementation Coordination Group (SURICG) provided in Appendix G to this paper be adopted.</td><td>Expected impact:
☐ Political /Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: The ToR from dissolved SEA/BOB ADS-B WG was reviewed and necessary updates were identified.</td><td colspan="2">Follow-up: ☐Required from States</td></tr>
<tr><td>When: 22-Oct-2021</td><td colspan="2">Status: Draft to be adopted by Sub-Group</td></tr>
<tr><td colspan="3">Who:☒Sub groups ☐ APAC States ☐ICAO APAC RO ☐ICAO HQ ☐APANPIRG ☐ Other:</td></tr>
</table>

Review ADS-B Implementation and Operations Guidance Document (AIGD) – Hong Kong China

2.36. Hong Kong China led the discussion and incorporation of materials to update AIGD during the meeting with amendments of the additional avionics issue on Honeywell Primus II RCZ as described in IP/07 of this meeting. The meeting reviewed that the updated document as provided in **Appendix H** to this paper and agreed to formulate the following draft Conclusion for consideration by CNS SG/25 meeting.

Draft Conclusion CNS SG/25/XX (SURICG/6/9) - Revised ADS-B Implementation and Operations Guidance Document (AIGD)

<table>
<tr><td colspan="2">What: That, the revised ADS-B Implementation and Operations Guidance Document (AIGD) provided in Appendix H to this paper, which consolidated all change proposals during SURICG/6, be adopted as Version 14.</td><td>Expected impact:
☐ Political / Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: Updates from SURICG/6</td><td colspan="2">Follow-up: ☐Required from States</td></tr>
<tr><td>When: 22-Oct-2021</td><td colspan="2">Status: Draft to be adopted by Subgroup</td></tr>
<tr><td colspan="3">Who: ☒CNS Sub group ☐APAC States ☒ICAO APAC RO ☐ICAO HQ</td></tr>
</table>

Resolution of conflicting provisions in the Doc 8071 Vol III regarding Flight Inspections (IP/12) – Singapore

2.37. Singapore informed the conflicting provisions in two Appendices A and B of Doc8071 Vol III on the requirement of flight inspections for surveillance radar systems. While the Appendix A of Doc 8071 Vol III stated that flight check is required only during commissioning, unless there is specific problem investigation, or deemed necessary by the maintenance personnel, Appendix B of Doc 8071 Vol III implied that there must be flight inspections every 120 days. The meeting was informed that it was discussed in Surveillance Panel members that most ANSPs perform flight checks based on Appendix A of Doc 8071 (i.e. during commissioning unless deemed necessary or for problem investigation) hence changes to Appendix B of Doc 8071 was suggested, which is subject to acceptance by the SP-ASWG during its meeting on 1-5 Nov 2021.

Other Papers of Updates on Surveillance Activities from States/Administrations

2.38. The SURICG/6 reviewed following papers on updates on surveillance activities from States/Administrations:-

- Automatic Dependent Surveillance-Broadcast (ADS-B) Out Implementation in USA (IP/05)
- New Zealand Surveillance Update (IP/15)
- ATC Surveillance Activities Update in Malaysia (IP/16)
- The Update Activity of ATC Surveillance in China (IP/20)

Date and Venue for the Next Meeting

2.39. The meeting discussed the next time to meet, and agreed that SURICG/7 was tentatively scheduled for May 2022 in a hybrid mode of meeting (face-to-face meeting with option to join via video conference).

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note and review on the information and discussion in this paper;
b) adopt the Draft Conclusion defined in **Section 2.3**;
c) adopt the Draft Conclusion defined in **Section 2.5**;
d) adopt the Draft Conclusion defined in **Section 2.6**;
e) adopt the Draft Conclusion defined in **Section 2.7**;
f) adopt the Draft Conclusion defined in **Section 2.8**;
g) adopt the Draft Decision defined in **Section 2.13**;
h) adopt the Draft Conclusion defined in **Section 2.21**;
i) adopt the Draft Decision defined in **Section 2.35**;
j) adopt the Draft Conclusion defined in **Section 2.36**; and
k) discuss any matters as appropriate.

– – – – – – – – – – – –

TABLE FOR SSR MODE S IIINTERROGATOR CODE COORDINATION

Explanation of the Table

Column

1	Name of ~~country/Territory~~ State/Administration and Location of the facility
2	Coordinates Latitude and Longitude
3	AMSL – Elevation of Radar head above the Means Sea Level in meters
4	Air Traffic Services Unit served by the facility
5	Coverage of SSR Mode S Radar in range (nautical miles)/Altitude(flight level)/Sector(degree)
6	~~SIC - System Identifier Code in decimal~~ Coverage of Lockout be implemented in range (nautical miles)/Altitude(flight level)/Sector(degree)
7	II Code – Interrogator Identifier in decimal
8	SI Code – Surveillance Identifier in decimal
9	Ability to be configured to perform technique described in Doc 9924 App H 1.2.6[1], 1.2.7[2], 1.2.8[3] 1.2.9[4] and 1.2.10[5].
~~8~~10	Remarks

[1] The interrogator, when operating with an SI code, must be configurable by the user to accept Mode S-only all-call replies for which the "matching" II code has been used to encode the parity sequence. *(Doc 9924 App H 1.2.6)*

[2] The target which has sent such replies must be considered as equipped with a non-SI capable transponder, even if the content of Register 10^{16} states that the transponder has the SI capability *(Doc 9924 App H 1.2.7)*

[3] The interrogator, if operating with an SI code, must be configurable by the user to interrogate targets equipped with non-SI capable transponders using the Mode S-selective protocols foreseen for II code operation. The II code to be used must be the "matching" II code. *(Doc 9924 App H 1.2.8)*

[4] The interrogator, if operating with an SI code, must be configurable by the user to either:
a) not lockout non-SI capable transponders on the "matching" II code; or
b) use intermittent lockout for this "matching" II code. *(Doc 9924 App H 1.2.9)*

[5] The interrogator, if operating with an II code, must be configurable by the user to either:
a) not lockout Mode S transponders that do not report the SI capability in Register 10_{16}; or
b) use intermittent lockout for Mode S transponders that do not report the SI capability in Register 10^{16}. *(Doc 9924 App H 1.2.10)*

SAMPLE TABLE

State/Territory Location	Coordinates		AMSL Meter	ATS UNIT served	Coverage NM/Flt/ Degree	SIC Lockout map NM/Flt/ Degree Decimal	II Code Decimal	SI Code Decimal	Able to comply wz Doc 9924 App H 1.2.6 to 1.2.10 (Y/N)	Remarks
	LAT	LONG								
1	2		3	4	5	6	7	8	9	810
MACAO, CHINA	22˚ 07’ 14’’N	113˚ 33’43’’E	175.1 M	Macao TWR	200 NM/ 45000 ft		08	-	Y	Nil
REPUBLIC OF KOREA										
Gimhae	35˚ 10’ 22’’ N	128˚ 55’55’’E	60	Gimhae APP	200		04	-	Y	
				Gimhae TWR						
Gimpo	37˚ 32’ 52’’ N	126˚ 47’40’’E	44	Incheon ACC	200		03	-	Y	
				Seoul APP						
				Incheon TWR						
Incheon (Sinbul)	37˚ 27’ 20’’ N	126˚ 28’50’’E	72	IncheonACC	200		02	-	Y	
				Seoul APP						
				Incheon TWR						
Incheon (Wangsan)	37˚ 28’ 00’’ N	126˚ 21’42’’E	173	Incheon ACC	200		01	-	Y	
				Seoul APP						
				Incheon TRR						

SAMPLE TABLE

II/SI Code Decimal	Location	State/Administration	Coordinates		AMSL Meter	ATS UNIT served	Coverage NM/Flt/ Degree	Lockout map NM/Flt/ Degree	Able to comply wz Doc 9924 App H 1.2.6 to 1.2.10 (Y/N)	Remarks
			LAT	LONG						
1	2	3	4		5	6	7	8	9	10
No II/SI Code										
	KANSAI NO. 1	JPN	34°26'35" N	135°15'12" E	56.2	KANSAI A/P	100NM/ FL/ DEG	NM/ FL/ DEG		
II Code 01 - Matching SI codes (SI 01, SI 17, SI 33, SI 49)										
01	Incheon (Wangsan)	KOR	37˚ 28’ 00’’N	126˚ 21’42’’E	173	Incheon ACC	200		Y	
						Seoul APP				
						Incheon TRR				
II Code 02 - Matching SI codes (SI 02, SI 18, SI 34, SI 50)										
02	Incheon (Sinbul)	KOR	37˚ 27’ 20’’N	126˚ 28’50’’E	72	Incheon ACC	200		Y	
						Seoul APP				
						Incheon TWR				
II Code 03 - Matching SI codes (SI 03, SI 19, SI 35, SI 51)										
03	Gimpo	KOR	37˚ 32’ 52’’N	126˚ 47’40’’E	44	Incheon ACC	200		Y	
						Seoul APP				
						Incheon TWR				

II/SI Code Decimal	**Location**	**State/Administration**	**Coordinates**		**AMSL Meter**	**ATS UNIT served**	**Coverage NM/Flt/ Degree**	**Lockout map NM/Flt/ Degree**	**Able to comply wz Doc 9924 App H 1.2.6 to 1.2.10 (Y/N)**	**Remarks**
			LAT	**LONG**						
1	**2**	**3**	**4**		**5**	**6**	**7**	**8**	**9**	**10**
II Code 04 - Matching SI codes (SI 04, SI 20, SI 36, SI 52)										
04	Gimhae	KOR	35˚ 10’ 22’’	128˚ 55’55’’	60	Gimhae APP	200		Y	
						Gimhae TWR				
…										
II Code 08 - Matching SI codes (SI 08, SI 24, SI 40, SI 56)										
08	**MACAO, CHINA**	MAC	22˚ 07’ 14’’	113˚ 33’43’’	175.1 M	Macao TWR	200 NM/ 45000 ft		Y	Nil
SI Code 01 - Matching II code (II 01)										
…										
SI Code 39 - Matching II code (II 07)										
SI Code 40 - Matching II code (II 08)										

Roadmap for Mode S DAPs Implementation in APAC Region

(Agreed by Mode S DAPs WG/4 and SURICG/6)

1. INTRODUCTION

1.1 The Terms of Reference for the Mode S DAPs Working Group includes the formulation of a roadmap for DAPs Application.

1.2 An initial version of the roadmap was generated at Mode S DAPs WG/3 for ~~consideration~~ adopted by SURICG/6~~5~~.

1.3 The topics considered in the roadmap were:

a) Mode S mandate;
b) Use of II and SI mixed Codes;
c) Radar Clustering;
d) Use of conspicuity codes;
e) Weather reporting capability; and
f) Datalink Map.

1.4 However, due to the evolving and complex nature of Mode S related technology, only the roadmap of *Mode S mandate* was adopted after some amendment.

1.5 Based on current practices around the world and taking into account the situation in Asia Pacific, the Mode S DAPs WG/4 formulated the revised version of roadmap for the Asia Pacific Region.

2. SUMMARY

The revised roadmap is summarised as follows:

S/N	Issue	Proposed Roadmap	Reasons
1	Mode S Mandate	**Conclusion APANPIRG/31/14 (CNS SG/24/13 (SURICG/5/3(DAPs WG3/1))) - Mode S Forward Fit Equipage in APAC Region** That, States/Administrations in APAC Region be strongly encouraged to mandate that registered aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, with a date of manufacture on or after 1 January 2022 be equipped with Mode S avionics compliant with Enhanced Surveillance (EHS).	Considering that a number of DAPs applications will require EHS and that it's easy for new aircraft to be equipped with EHS. Retrofitting existing airframes with EHS will need further deliberation under challenging pandemic situation.
2	Use of II and SI mixed Codes	**Proposed Draft Conclusion** States with Mode S radar capable of performing II/SI mode operations are urged to transit from II code to II and	Due to higher density of radars, some states are facing a shortage of IC codes, which has to be solved by transiting from II to II and SI mixed code. It is noted that

		SI mixed code, so as to ease the shortage of II codes. States planning to perform the transition shall coordinate with ICAO APAC to obtain the SI codes.	radars using II and SI codes can co-exist, hence there is no need for a big bang approach. However, States still have to coordinate with ICAO APAC on the allocation of SI codes. Due to some aircraft still not SI code ready, only radars with II/SI mode should be allowed to use SI
3	Radar Clustering	No proposed roadmap at the moment. But States with the competency and operational requirement may consider applying such technique.	Due to complexity and cost, only Germany and the Netherlands have implemented such techniques. It is unclear whether the benefits outweigh the cost.
4	Use of conspicuity codes	Mode A = 1000 has already being assigned as the conspicuity code.	It is foreseen that the region will need the automation systems to be able to support the conspicuity code feature before Mode S address can be used in lieu of Mode A address for selected flights. There may be a need to coordinate the efforts with ATMAS TF in the region.
5	Weather reporting capability	Not practical to mandate weather reporting capability in Mode S, as there are no ready solutions to enable such capability for current transponders (i.e. versions 0, 1, and 2). States requiring such capability should consider other means to generate weather information (such as using algorithm to derive weather information).	While weather data is one of the Mode S DAPs, only very few (<1%) aircraft has this capability. The industry does not have software patches to enable this weather feature, hence there is no point having a mandate for weather capability. Instead, some States researched algorithms to derive weather information. It is foreseen that the weather reporting capability will be available in version 3 transponders
6	Datalink Map	No proposed roadmap at the moment. States are instead urged to adopt the various SARPs and guidance material relating to reduction of frequency congestion.	It is difficult to implement and enforce datalink map with no certainty of success. It is more practical to adopt the SARPs and guidance materials relating to the reduction of frequency congestion.
7	Monitoring of 1030 and 1090 MHz usage	States with capability are urged to perform RF measurement on 1030 and 1090 MHz usage. Guidance material is proposed.	It is necessary to ensure that the RF occupancy is kept at healthy levels.

Note: The roadmap may be revisited as and when necessary. It is foreseen that for the items without roadmap, they may be reviewed in 2 to 3 year time.

CNS SG/25
Appendix C to WP/13

INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

MODE S DOWNLINK AIRCRAFT PARAMETERS IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT

Edition 3.0 - March 2021

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PREFACE

This publication is one of the deliverables of the Mode S DAPs WG according to the Terms of Reference (TOR). It aims at providing guidance materials to States and airspace users on the use of Mode S DAPs in the Asia and Pacific Regions from both operational and technical perspectives. A working team was established to develop the contents, and China has volunteered to take lead on coordinating and consolidating inputs from members of the working team.

During Mode S DAPs WG/1 held in March 2018, the meeting considered that further development work is required before the initial draft (Edition 0.1) proposed by China and Hong Kong China becomes ready for approval. Then the working team began to develop the contents of the guidance document, China organized two internal conferences and ICAO APAC office organized a web conference for reviewing the contents. Based on numerous rounds of review and comments with joint efforts from the working team, China has revised the draft into five previous versions. Finally, Edition 1.0 was submitted for endorsement after Mode S DAPs WG/2, and published in the CNS SG/23. China revised the document and circulated it to the members of the Working Group for comments. Then Edition 2.0 was released in 2020, during CNS SG/24. The revised draft (Edition 3.0) is proposed to Mode S DAPs WG/4, and then is endorsed by the meeting.

The support from ICAO APAC Office and contributions from the following volunteer State/Administration and industry partner in preparing the guidance material is acknowledged and highly appreciated:

- Air Traffic Management Bureau of CAAC, China
- The Second Research Institute of CAAC, China
- Hong Kong Civil Aviation Department, China
- Civil Aviation Authority of Singapore
- Japan Civil Aviation Bureau
- Electronic Navigation Research Institute, Japan
- Airways, New Zealand
- Airservices, Australia

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Purpose

This Mode S Downlink Aircraft Parameters Implementation and Operations Guidance Document (DAPs IGD) provides guidance for the planning, implementation and operational application of Mode S DAPs technology in the Asia and Pacific Regions.

The procedures and requirements for Mode S DAPs operations are detailed in the relevant States' AIP. This IGD is intended to provide key information on Mode S DAPs performance, integration, principles, procedures and collaboration mechanisms.

The content is based upon the work to date of the Mode S DAPs Working Group and various ANC Panels for the operational use of Mode S DAPs.

1.2 Background

1.2.1 Mode S and DAPs

Mode S (Select) is an extension of conventional SSR which permits selective addressing of individual aircraft equipped with Mode S transponders. Additional data known as Downlink Aircraft Parameters (DAPs) may also be extracted from the aircraft, including aircraft identification which should correspond to the ACID entered in the flight plan.

Mode S operates on the same radio frequencies (1030 and 1090 MHz) as conventional SSR systems, allowing for interrogation of Mode A/C only transponders and Mode S transponders.

Each Mode S equipped aircraft is assigned a unique ICAO 24-bit aircraft address. Using the selective interrogation capability of the Mode S SSR, Mode S Sensors are able to first acquire and then selectively interrogate a specific aircraft via its unique ICAO 24-bit aircraft address. This significantly improves the radar's detection and tracking performance, and therefore improving the ability of ATC to monitor and control the aircraft, as well as the others around it.

The innovation of Mode S resides in the use of selective addressing of aircraft which offers technical advantages over conventional SSR, such as reducing "fruit" and "garbling", providing higher integrity radar tracks.

Mode S technology has the following characteristics:

a) selective interrogation,

b) individual aircraft address and

c) datalink capability.

The Mode S application includes Mode S radar system, datalink Systems, MLAT Systems, etc.

Various avionics systems onboard an aircraft receive data from sensors to provide the DAPs output. The data mainly comes from several sets of sensors, such as air data sensors (including pitot probe, static port, temperature sensor, and angle of attack sensor), inertial sensors (including position gyroscopes, rate gyroscopes and accelerometers) and magnetic sensor(s). Part of the parameters produced by other avionics systems (such as MCP/FCU, FMS, TCAS, etc.) is also defined as downlink aircraft parameters. These parameters are then sent to the transponder through standard data buses, and stored inside the relevant transponder's 56-bit Binary Data Storages (BDS). Ground-based surveillance systems (such as MSSR or MLAT) can downlink the desired parameters using specific Mode S protocols.

For detailed information about DAPs data source, please refer to Appendix 3.

Mode S DAPs is an application of the Mode S Datalink System. The downlink standard length transaction interface shall deliver DAPs to the transponder which then makes data available to the ground surveillance systems. Each DAP shall be packed into the Comm-B format ('MB' field) and can be extracted using either the ground-initiated Comm-B (GICB) protocol, or using MSP downlink channel 3 via the data flash application.

1.2.2 Benefit of Mode S and Use of DAPs

The Mode S application reduces the weakness of Mode A/C, because of the selective interrogation reducing synchronous garble and asynchronous interference. The parity check technique improves the reliability and integrity of surveillance data. The availability of almost 17 million unique aircraft addresses, in conjunction with the automatic reporting of flight identity, alleviates Mode 3/A code shortages and enables unambiguous aircraft identification, if the correct aircraft address and/or Aircraft Identification are entered in both the flight plan and aircraft systems. The datalink technique assists the acquisition of downlink aircraft parameters, and the additional track label information improves the air situational awareness. The controller and pilot are presented with improved situation awareness, which reduces the R/T workload.

Another benefit is to maximize SSR Mode 3/A code savings. By introducing the Mode S Conspicuity Code, all aircraft identified by Mode S via DAPs (ACID) can use the same SSR Mode 3/A code. During the 6th meeting of ATM SG, the following Conclusion is adopted:

Conclusion ATM/SG/6-3: Proposed Air Navigation Plan Volume II Amendment

'A1000' was reserved for the Mode S Conspicuity Code for the ICAO APAC region.

1.3 Arrangement of DAPs IGD

The Mode S DAPs Implementation and Operations Guidance Document consists of the following parts:

Section 1	Introduction
Section 2	Acronym Lists
Section 3	Reference Documents
Section 4	Description of Mode S DAPs Data
Section 5	Implementation Principles and Phase
Section 6	System Integrity and Monitoring
Section 7	Regulations and Procedures
Section 8	Training and Competence
Section 9	Specific Examples on Mode S DAPs Applications

1.4 Document History and Management

The framework of this document was introduced in the first Working Group Meeting of Mode S Downlink Aircraft Parameters in March 2018. The Meeting agreed to further develop based on the proposed framework to a complete document for approval as a regional guidance document. A working team, consisting of volunteers from China, Hong Kong-China, Japan, Malaysia, Singapore, Thailand and

New Zealand was established by the Meeting to contribute to the content of the document. In July 2018, the completed draft of this document was ready for circulation among States for review and comment.

The aim of this document to supplement SARPs, PANS and relevant provisions contained in ICAO documentation and it will be regularly updated to reflect evolving provisions.

1.5 Copies

Paper copies of this DAPs IGD are not distributed. Controlled and endorsed copies can be found at the following website: http://www.icao.int/APAC/Pages/edocs.aspx and may be freely downloaded from the website, or by emailing APANPIRG through the ICAO Asia and Pacific Regional Office who will send a copy by return email.

1.6 Changes to DAPs IGD

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (see Section 1.8 below) should be completed and submitted to the ICAO Asia and Pacific Regional Office. The Regional Office will collate RFCs for consideration by the Surveillance Implementation Coordination Group.

When an amendment has been adopted by the meeting of the Surveillance Implementation Coordination Group, then a new version of the DAPs IGD will be prepared, with the changes marked by an "|" in the margin, and an endnote indicating the relevant RFC, so a reader can see the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted; e.g.:

Final approval for publication of an amendment to the DAPs IGD will be the responsibility of APANPIRG.

1.7 Editing Conventions

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1.8 DAPs IGD Request for Change Form

RFC Nr:	

Please use this form when requesting a change to any part of this DAPs IGD. This form may be photocopied as required, emailed, faxed or e-mailed to ICAO Asia and Pacific Regional Office +66 (2) 537-8199 or APAC@icao.int

1. SUBJECT:				
2. REASON FOR CHANGE:				
3. DESCRIPTION OF PROPOSAL: [expand / attach additional pages if necessary]				
4. REFERENCE(S):				
5. PERSON INITIATING:			**DATE:**	
ORGANISATION:				
TEL/FAX/E-MAIL:				
6. CONSULTATION	**RESPONSE DUE BY DATE:**			
Organization	**Name**	**Agree/Disagree**	**Date**	
7. ACTION REQUIRED :				
8. DAPs IGD EDITOR		**DATE REC'D :**		
9. FEEDBACK PASSED		**DATE :**		

1.9 Amendment Record

Amendment Number	Date	Amended by	Comments
0.1	20 March 2018	China Hong Kong, China	Initial draft for consideration by Mode S DAPs WG/1
0.2	1 August 2018	China Hong Kong, China Japan Singapore Malaysia	First completed draft based on the agreed document framework in Mode S DAPs WG/1 for review and comment by States
0.3	23 August 2018	China	Based on Version 0.2 draft, China hold a meeting to discuss problems respecting the first completed draft. This is a revised document according to content of this meeting.
0.3.1	26 September 2018	China Hong Kong, China Singapore New Zealand	Based on Version 0.3 draft, States make a full comment on the content of IGD. This is a revised document according to those comments.
0.3.2	6 November 2018	China New Zealand Hong Kong, China Singapore Malaysia	Based on Version 0.3.1 draft, States discussed all comments of IGD in the Mode S DAPs WG 1st Web Conference. This is revised by the meeting decisions.
0.4	27 December 2018	China New Zealand Singapore Australia	Based on Version 0.3.2, States review and comment on the IGD. This is a revised document according to those comments.
1.0	14 March 2019	China Japan Singapore Malaysia	Consideration by Mode S DAPs WG/2
1.1	17 February 2020	China New Zealand Singapore	Modify based on Version 1.0, States review and comment on the IGD.
2.0	13 May 2020	China	Consideration by Mode S DAPs WG/3
3.0	March 2021	China	

2. ACRONYMS LIST

AA	Aircraft Address
AC	Altitude Code
ACID	Aircraft Identification
ADS-B	Automatic Dependent Surveillance-Broadcast
AICB	Air-Initiated Comm-B
AIP	Aeronautical Information Publication
ANC	Air Navigation Conference
ANSP	Air Navigation Service Provider
APAC	Asia Pacific
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Service
ATSEP	Air Traffic Safety Electronic Personnel
BDS	Comm-B Data Selector
CA	Capability
CDTI	Cockpit Display Traffic Information
CFL	Cleared Flight Level
CLAM	Cleared Level Adherence Monitoring
CNS	Communications, Navigation and Surveillance
DAPs	Downlink Aircraft Parameters
DF	Downlink Format
EASA	European Aviation Safety Agency
EHS	Mode S Enhanced Surveillance
ELM	Extended Length Message
ELS	Mode S Elementary Surveillance
ES	Extended Squitter
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTORL	European Organization for the Safety of Air Navigation
FIR	Flight Information Region
FLTID	Flight Identification (transmitted by aircraft)
FMS	Flight Management System
FS	Flight Status
FRUIT	False Relies Unsynchronized In Time
GICB	Ground-Initiated Comm-B
HMI	Human Machine Interface
IC	Interrogator Code
ICAO	International Civil Aviation Organization
ID	Identity
IFR	Instrument Flight Rules
II	Interrogator Identifier
IRF	Interrogation Repetition Frequency
MHz	Megahertz
MIP	Mode Interlace Patterns
MIT	Massachusetts Institute of Technology
MLAT	Multilateration
MSAW	Minimum Safe Altitude Warning
MSP	Mode S Specific Protocol
MTCD	Medium Term Conflict Detection
SARPs	(ICAO) Standards and Recommended Practices
SFL	Selected Flight Level

SI	Surveillance Identifier
SSR	Secondary Surveillance Radar
STCA	Short-Term Conflict Alert
UTC	Universal Time Coordinated
WAM	Wide Area Multilateration
WG	Working Group

3. REFERENCE DOCUMENTS

Id	Name of the document	Edition	Date	Origin	Domain
1	Aeronautical Telecommunications, Annex 10 - Vol. III - Communication Systems	Edition 2	2007	ICAO	
2	Aeronautical Telecommunications, Annex 10 - Vol. IV - Surveillance Radar and Collision Avoidance Systems	Edition 5	2014	ICAO	
3	Doc 9871, Technical Provisions for Mode S Services and Extended Squitter.	Edition 2	2012	ICAO	
4	Doc 9688 Manual on Mode S specific service.	Edition 2	2004	ICAO	
5	ED-73E, Minimum Operational Performance Standards for Secondary Surveillance Radar Mode S Transponders.	Edition 1	May 2011	EUROCAE	
6	ADS-B Implementation and Operations Guidance Document	Edition 11	April 2018	ICAO APAC	
7	Concept of Operations Mode S in Europe (Mode S CONOPS)	Edition 2	November 2013	Eurocontrol	
8	Mode S Elementary Surveillance (ELS) Operations Manual	Edition 1	January 2011	Eurocontrol	
9	Asia/Pacific Seamless ATM Plan		May 2015	ICAO APAC	
10	Doc 9924 Aeronautical Surveillance Manual	Second Edition	2017	ICAO	
11	Preliminary System Safety Analysis for the Mode S Elementary Surveillance	Edition 1.8	April 2004	Eurocontrol	EATMP
12	Elementary Surveillance (ELS) and Enhanced Surveillance (EHS) validation via Mode S Secondary Radar		April 2008	MIT Lincoln Laboratory	ATC Project
13	Aircraft Derived Data Validation Algorithms		August 2012	MIT Lincoln Laboratory	ATC Project
14	Doc.4444 Procedures For Air Navigation Services Air Traffic Management	Sixteenth Edition	November 2016	ICAO	
15	Clarification Mode S Transponder in an Airport/A-SMGCS Environment	Edition 1.1	3 May 2005	Eurocontrol	

16	Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System /Mode Select (ATCRBS / Mode S) Airborne Equipment	Edition E	17 March 2011	RTCA	
17	MARK 4 AIR TRAFFIC CONTROL TRANSPONDER (ATCRBS/MODE S)	Edition 4	15 November 2011	ARINC	

4. DESCRIPTION OF MODE S DAPs DATA

Inside the aircraft transponder, DAPs are stored in different BDS Registers for responding to DAPs interrogation requests by a Mode S ground system. Aircraft parameters are periodically delivered from aircraft sensors, flight management system, etc., to these registers via the downlink standard length transaction interface. BDS Registers, which have not been updated within the specified maximum update interval, are cleared or indicated as invalid and such aircraft parameters would be unavailable for ground interrogations. When a Mode S SSR sends an interrogation requesting the downlink of registers, DAPs are packed into Comm-B format (known as "MB" field) and are extracted using either the GICB protocol or Mode S specific protocols (MSPs) channel 3.

BDS Registers are identified by a two-digit hex number. For example, BDS Register for selected vertical intention, which is identified by hex number 40_{16}, is commonly written as BDS code 4, 0 in publications. Depending on the stage of Mode S implementation, i.e. Mode S ELS and Mode S EHS, the scope of Mode S DAPs data involved would be different as illustrated in the following subsections.

Detailed data format and maximum update interval of each BDS register are given in "ICAO Doc 9871 - Technical Provisions for Mode S Services and Extended Squitter".

4.1 Mode S ELS

In Mode S ELS implementation, aircraft and ground Mode S system should be compliant with providing the following functionalities over conventional Mode A/C systems:

a) Selective interrogation;

b) Use of ICAO Aircraft Address;

c) Automatic reporting of ACID;

d) Report of transponder capability;

e) Altitude reporting with a resolution of 25ft (subject to aircraft capability);

f) Provision of flight status to indicate airborne or on-the-ground (subject to aircraft capability);

g) Report of SI Code capability; and

h) ACAS active resolution advisory report (when equipped with TCAS)

DAPs associated with Mode S ELS are stored in BDS code 1,0, BDS code 1,7, BDS code 2,0 and BDS code 3,0 registers of the aircraft's transponder.

Table 4-1 DAPs in Mode S ELS

Register	Name	Usage
BDS code 1,0	Datalink Capability Report	To report the data link capability of the Mode S transponder/data link installation.
BDS code 1,7	Common Usage GICB Capability Report	To indicate common usage GICB services currently supported.
BDS code 2,0	Aircraft Identification	To report aircraft identification to the ground.
BDS code 3,0	ACAS Resolution Advisory Report	To report ACAS active resolution advisory

With the above functionalities properly configured, Mode S ELS could bring the following benefits to ATC operations:

a) Provide unambiguous aircraft identification using the unique aircraft address and aircraft identification;

b) Help to solve Mode 3/A code shortage in congested airspace, using the Mode S conspicuity code (A1000) instead of discrete Mode 3/A codes;

c) Improve surveillance data integrity by;

   1) reducing synchronous garble*,

   2) lessening over-interrogations, and

   3) simplifying aircraft identification in case of false targets;

d) Improve the accuracy of multi-surveillance tracking and safety nets with more accurate target detection from Mode S radars and high resolution in altitude reporting; and

e) Able to process more aircraft tracks than conventional Mode A/C radars; and

f) Able to provide ACAS active resolution advisory from suitably equipped aircraft.

*Note, while Mode S will help to reduce data garble it will not resolve the issue. Issues around multi-path and different transponder types in close proximity (e.g. Mode A/C near a Mode S transponder) mean that the return received by the radar may not be correct. In the case of a Mode A/C transponder close to a Mode S transponder, instances have been recorded where the Mode S address has been transposed into the reply from the Mode A transponder.

4.2 Mode S EHS

Mode S EHS implementation includes all the features of Mode S ELS with the addition of DAPs stored in BDS code 4,0, BDS code 5,0 and BDS code 6,0 registers of the aircraft's transponder. The following table summarizes the details of DAPs of these three registers:

Table 4-2 DAPs in Mode S EHS

Register	Name/Downlink Aircraft Parameters		Usage
BDS code 4,0	Selected Vertical Intention	MCP/FCU Selected Altitude	To provide information about the aircraft's current vertical intentions
		FMS Selected Altitude	
		Barometric Pressure Setting	
		MCP/FCU Mode	
		Target Altitude Source	
BDS code 5,0	Track and Turn Report	Roll Angle	To provide track and turn data to the ground systems.
		True Track Angle	
		Ground Speed	
		Track Angle Rate	
		True Air Speed	
BDS code 6,0	Heading and Speed Report	Magnetic Heading	To provide heading and speed data to ground systems.
		Indicated Air Speed	
		Mach Number	
		Barometric Altitude Rate	
		Inertial Vertical Velocity	

In addition to those improvements contributed by Mode S ELS in Section 4.1, Mode S EHS implementation provides the following benefits to ATC operation:

a) Further improve multi-surveillance tracking accuracy and performance through the use of DAPs on track, turn, speed and heading of the aircraft in the track calculation;

b) Further improve the accuracy of safety nets, e.g. Short-Term Conflict Alert (STCA), through the provision of more accurate aircraft tracks, and Medium Term Conflict Detection (MTCD), Minimum Safe Altitude Warning (MSAW), through the provision of the earlier judgment of vertical movement;

c) Allow the implementation of new safety nets in ATM automation system for cross-checking selected aircraft vertical intention (i.e. Selected Altitude) with ATC controllers' instruction as well as verifying the barometric pressure setting applied in the aircraft with QNH setting in ATM automation system; and

d) Improve situational awareness of ATC controllers by enabling the direct access of aircraft parameters in ATM automation system, e.g. Indicated Air Speed, Mach speed, Selected Altitude, Barometric Pressure Setting, etc.;

e) Progressive reduction of R/T workload per aircraft.

4.3 DAPs Data Exchange Protocol Between Surveillance and ATM Automation System

The decoding of DAPs data from downlink messages is handled by ground surveillance equipment such as radars, ADS-B, MLAT and WAM ground stations. The Surveillance Data Processor (SDP) within the ATM automation system can combine multiple downlink messages into a single target report for display to controllers. All Purpose Structured EUROCONTROL Surveillance Information Exchange (ASTERIX) formats are commonly used as the protocol for target report transmission from surveillance systems to the ATM automation system.

For detailed information about ASTERIX formats please refer to the following link of EUROCONTROL web site:

https://www.eurocontrol.int/asterix

ASTERIX formats are categorized based on the types of surveillance data involved. ASTERIX Category 20, ASTERIX Category 21 and ASTERIX Category 48 are responsible for the DAPs data transmission from MLAT systems, ADS-B systems and radars respectively. For each ASTERIX category, the protocol format is further divided into different editions with variations on the supported DAPs data. ANSP's should carry out appropriate studies on the available protocol editions during the design stage to ensure the chosen format can cater to the scope of DAPs proposed to be implemented and that the Surveillance and ATM automation systems can correctly process the protocol selected.

For details, previous and current versions of ASTERIX Category 20, Category 21 and Category 48 specification documents can be downloaded from the following link of EUROCONTROL web sites:

https://www.eurocontrol.int/publication/cat020-eurocontrol-specification-surveillance-data-exchange-asterix-part-14-category-20

https://www.eurocontrol.int/publication/cat021-eurocontrol-specification-surveillance-data-exchange-asterix-part-12-category-21

https://www.eurocontrol.int/publication/cat048-eurocontrol-specification-surveillance-data-exchange-asterix-part4

5. IMPLEMENTATION PRINCIPLES AND PHASES

Implementation guidance is developed to progress the DAPs implementation from concept to operational use in the ICAO APAC region. In this chapter, section one addresses the implementation principles, which describes the issues of international coordination, system compatibility, data integrity and system integration, while section two addresses the implementation phase, to assist States with the management of DAPs implementation activities.

5.1 Implementation Principles

5.1.1 Stakeholders Coordination

DAPs provide useful information from aircraft which can benefit ANSP and airspace users. Improvements in efficiency and safety can be achieved, however the resultant changes in operational procedures to provide the improvements, will affect ANSPs, Regulators, Airlines, and other related airspace users. Before implementation by any State, a coordination team should be formed to study, coordinate, support and consult the implementation plans and related activities. The coordination team should include field experts on avionics, data link, surveillance infrastructures and end users.

Changes in the ATM operational procedures as the result of the use of DAPs require coordination among ATS providers, Regulators, Airlines, and where applicable, coordination among neighboring States to maximize the benefits. All States are encouraged to share their operational experiences, and to report anomalies through Mode S DAPs WG and the Surveillance Implementation Coordination Group.

Not all Surveillance and ATM automation systems are capable of processing and using DAPs, therefore investment in all related fields needs to be considered by all States. The coordination team should be consulted for future investment plans and related activities considering the technical and operational aspects. Consideration needs to be given to achieve a balance between investment and benefits.

5.1.2 System Compatibility

a) Technical:

DAPs can be obtained by different surveillance technologies such as Mode S Radar, ADS-B, MLAT and WAM, however not all the transponders can support DAPs. Different surveillance technologies in the ICAO APAC States mean that system compatibility should be considered.

Potential interference between different surveillance technologies should be fully considered before implementation, otherwise the efficiency and safety of the system cannot be ensured. Harmonization between different technologies should be considered and optimized to reduce the RF congestion on 1030MHz and 1090MHz.

Since not all aircraft are equipped with Mode S transponders, and not all the Mode S transponders have the ability to support DAPs, compatibility and efficiency should always be considered before implementation.

When DAPs are implemented, the data rate will increase compared to the conventional radar data, and the related BDS information extraction strategies should be considered. To reduce the load on the 1090MHz spectrum, only those registers intended for operational use should be interrogated/extracted.

b) Operational:

Different processing systems can support DAPs in different levels, hence the quality and information of the target may be different after the processed DAPs have been added. For example, some radar tracking algorithms will consider DAPs as an input to the tracking, so the quality and information of the target will be a little bit different, therefore there should be compatibility considerations between different systems before use of the target data.

There are different air traffic management and operation strategies used by neighboring States. So, the operational procedures should always consider the operational compatibilities. For example, Mode A/C transponders and Mode S transponders may be working in the same area.

5.1.3 DAPs Data Integrity

DAPs data integrity should always be the first consideration when putting DAPs data into use. Since the data integrity from the source is not delivered by any related BDS register now, States are encouraged to find a reliable methodology to ensure the data integrity before the use of the data. Additionally, ongoing means of determining data integrity should be implemented, along with an ability to exclude invalid DAPs data from ATM automation systems.

States which already have experience on data integrity are encouraged to share this information with other States. The coordination team could support and harmonize this activity, and provide a standard method to evaluate the data integrity, and share the method with all the States.

5.1.4 System Integration

By introducing DAPs, the target characteristic from the source to the end user may be different compared to pre-DAPs implementation. In different phases of the processing flow of target data, DAPs can be used by different systems to improve tracking performance. Some key points in the data flow are as follows:

a) Airborne Avionics Systems

As DAPs data comes from different kinds of sensors and avionics systems on the aircraft, the reliability of the data should be ensured before the data is used operationally. Research has shown that some BDS data is missing or not updated correctly. The reasons for this need to be established, as it can mean that the use of some DAPs data is not suitable for implementation. Examples of issues include:

1) Older Flight Management Systems which do not provide all the DAPs data, and
2) Incorrect installation (e.g. onboard equipment wired to wrong registers)

b) Ground Sensor Systems

Ground sensors may use the DAPs to improve their target tracking performance, having an impact on the tracking function; the target data produced by this kind of sensors will show different characteristics to the pre-DAPs implemented tracking function, such as the turning rate, the kinematic movement and so on. Data users need to be aware of this performance improvement.

c) Ground Automation Systems

Ground automation systems can use DAPs information for a wide variety of uses, such as for tracking, safety net processing, situational awareness, en-route meteorological information sharing and so on. Ensuring DAPs information is processed and used in an appropriate way should be considered during implementation.

d) Other Surveillance Systems

Any DAPs data should be capable of being integrated with other surveillance systems data, and any potential difference and impact should be considered before use. Some of the information can be cross checked by different surveillance technologies.

e) Other Related Systems

5.2 Implementation CHECKLIST

The purpose of this implementation checklist is to document the range of activities that need to be completed to bring a DAPs application from an initial concept to operational use. Some activities of this checklist may be specific to individual stakeholders.

5.2.1 Activity Sequence

The activities are listed in approximate sequential order. However, each activity does not have to be completed prior to starting the next activity. In many cases, a parallel and iterative process should be used to feed data and experience from one activity to another. It should be noted that not all activities will be required for all applications.

5.2.2 Concept Phase

a) Construct operational concept:
   1) Purpose;
   2) Operational environment;
   3) ATM functions; and
   4) Infrastructure;

b) Identify benefits:
   1) Safety enhancements;
   2) Efficiency;
   3) Capacity;
   4) Environmental;
   5) Cost reductions;
   6) Accessibility; and
   7) Other metrics (e.g. predictability, flexibility, usefulness);

c) Identify constraints:
   1) Air-Ground interoperability;
   2) Compatibility with non-equipped aircraft;
   3) Need for exclusive airspace;
   4) Required ground infrastructure;
   5) RF spectrum;
   6) Integration with existing technology;
   7) Technology availability; and
   8) Actuality of existing infrastructure;

d) Prepare business case:
   1) Cost benefit analysis; and
   2) Demand and justification.

5.2.3 Design Phase

a) Identify operational requirements:
   1) Security; and
   2) Systems interoperability;

b) Identify human factors issues:
   1) Human-machine interfaces;
   2) Training development and validation;
   3) Workload demands;
   4) Role of automation vs. role of human;
   5) Crew coordination/pilot decision-making interactions; and
   6) ATM collaborative decision-making.

c) Identify technical requirements:
   1) Standards development;
   2) Prevailing avionics standards;
   3) Data required;
   4) Functional processing;
   5) Functional performance;
   6) Required certification levels; and
   7) Identify the infrastructure that needs upgrade.

d) Equipment development, test, and evaluation:
   1) Prototype systems built to existing or draft standards/specifications;
   2) Upgrade and test scheme for the existing infrastructure;
   3) Developmental bench and flight tests;
   4) Acceptance test parameters; Acceptance test should be performed to ensure all the key indicators are met; and
   5) Select and procure technology.

e) Develop procedures:
   1) Pilot and controller actions and responsibilities;
   2) Standardize the interaction and phraseologies;
   3) Controller's responsibility to maintain a monitoring function, if appropriate;
   4) System certification procedure should be made.
   5) Standard Operating Procedure should be made if the human machine interface of the system is changed.

6) Contingency procedures; For example duplicate Mode S address is detected;
7) Emergency procedures, for example ACAS message is received;
8) General procedures for unforeseen issues should be made; and
9) Develop AIP and Information documentation.

f) Prepare design phase safety case:
1) Safety rationale;
2) Safety budget and allocation; and
3) Functional hazard assessment.

5.2.4 Implementation Phase

a) Prepare implementation phase safety case;

b) Conduct operational test and evaluation:
1) Flight deck and ATC validation simulations; and
2) Flight tests and operational trials;

c) Obtain systems certification:
1) Aircraft equipment; and
2) Ground systems;

d) Obtain regulatory approvals:
1) Air traffic certification of use;

e) Impact Assessment

An impact assessment should be conducted to gauge the effect in terms of security, efficiency, operating regulations, human factors, infrastructure, environment, and so on.

f) Implementation transition:
1) Promulgate procedures;

The regulatory authority shall promulgate general regulations to the participants. Each participant shall formulate corresponding detailed regulations.

2) Deliver training;

Training should be conducted to ensure the personnel is familiar with the standard, regulation, and technology of the Mode S DAPs implementation and operation. Licensing process could be executed if needed.

3) Continue data collection and analysis;
4) Resolve any unforeseen issues; and
5) Continue feedback into standards development processes;

g) Performance monitoring to ensure that the agreed performance is maintained.

6. SYSTEM INTEGRITY AND MONITORING

6.1 Introduction

CNS and ATM environment is an integrated system including physical systems (hardware, software, and communication networks), human elements (pilots, controllers and engineers), and the operational procedures for its applications. The integration of Mode S DAPs with other surveillance technologies enables more information from an aircraft to be used to provide a safer service.

Because of the integrated nature of such system and the degree of interaction among its components, comprehensive system monitoring is recommended. The procedures described in this section aim to ensure system integrity by validation, identification, reporting and tracking of possible problems revealed during system monitoring with appropriate follow-up actions.

6.2 Personnel Licensing and Training

Prior to operating any element of the Mode S DAPs system, operational and technical personnel shall undertake appropriate training as determined by the ANSP or State Regulatory Authority, including compliance with the Convention on International Civil Aviation where applicable. Such training will ensure that personnel are familiar with the regulation, standards and requirements of the Mode S DAPs implementation and operation.

6.3 ATS System Validation

6.3.1 Safety Assessment Guidelines

To meet system integrity requirements, ANSPs or States should conduct a validation process that confirms the integrity of their equipment and procedures. Such processes shall include:

a) A system safety assessment for new implementations is the basis for definitions of system performance requirements. Where existing systems are being modified to utilize additional services, the assessment demonstrates that the ATS Provider's system will meet safety objectives.

b) Integration test results confirming interoperability for operational use of airborne and ground systems; and

c) Confirmation that the ATS operation procedure is compatible with those of adjacent providers where the system is used across a common boundary.

6.3.2 System Safety Assessment

The objective of the system safety assessment is to ensure that the implementation and operation of Mode S DAPs are safe. The safety assessment should be conducted for implementation as well as any future enhancements and should include:

a) Identifying failure or error conditions;

b) Assigning levels of criticality;

c) Determining risks/probabilities for occurrence;

d) Identifying mitigating measures;

e) Categorizing the degree of acceptability of risks; and

f) Operational hazard ID process.

Following the safety assessment, States should institute measures to offset any identified failure or error conditions that are not already categorized as acceptable. This should be done to reduce the probability of their occurrence to an acceptable level. This could be accomplished through the automation of procedures.

6.3.3 Integration Test

States should conduct trials with suitably equipped aircraft to ensure the DAPs data meets the operational and technical requirements to provide ATS. The introduction of the Mode S DAPs will give more information about the aircraft, and should not affect the performance of the existing system. States should be satisfied by test results and analysis carried out by the ANSP.

6.3.4 ATS Operation Manuals

States may coordinate with adjacent States to confirm that their ATS operation manuals contain standard operating procedures to ensure harmonization of procedures that impact across common boundaries.

6.4 System Monitoring

During the implementation and operation of the Mode S DAPs technology, routine collection of data is necessary to ensure that the system continues to meet or exceed its performance, safety and interoperability requirements, and that operational service delivery and procedures are working as intended.

6.4.1 Consideration for System Monitoring

Mode S transponders may have been installed a long time ago to support mandatory ACAS functionality. The Mode A/C function has been permanently used by ATC, but the Mode S functions may not have been used. Any failure impacting Mode A/C would have been detected by ATC during normal operation and corrective action would have been undertaken. Before implementing Mode S for surveillance, system checks are usually made to ensure the correct operation of the Mode S transponders (e.g. continue to correctly process Mode A/C and Mode S replies), but possibly no system checks were made to ensure that the DAPs data was correct, so several undetected failures may have existed over the years of operation.

A number of Mode S transponder from different OEMs have been observed to be non-compliant with Annex 10 Volume IV requirements (e.g. no SI code capability, no reply to aircraft register extraction, incorrectly configured aircraft address, incorrect content of BDS registers), even though the transponder is certified to level 2. Although actions have been taken in some areas (mainly where Mode S has been implemented) to address these problems, some aircraft with Mode S which are not working correctly still operate (mostly in areas where Mode S has not yet been implemented).

During the initial deployment of European Mode S, it was discovered that avionics upgrade performed on some aircraft had resulted in erroneous transponder operations so that, in some cases, the aircraft could not even be detected by the ground radar. It is therefore recommended that before commencing Mode S surveillance operations in a given airspace, system monitoring be put in place for timely detection and rectification of hidden transponder problems. This will enable the ANSP and aircraft operators to remedy identified issues prior to using Mode S operationally.

The communication lines for transferring surveillance information in a Mode S radar require much higher data throughput as there is more information per aircraft. For example, compared to a Mode A/C radar, Mode S DAPs require up to three times more data throughput.

Mode S DAPs bring safety benefits even when only a portion of the traffic is properly equipped. Some aircraft can be configured to provide additional data items, but their use should be considered with caution since some airborne installations may not have been certified, hence data may be erroneous. System monitoring to validate the transmitted information is considered desirable for DAPs operation.

6.4.2 Mode S DAPs Problem Reports

During the application of the Mode S DAPs, some problems may be found during the observation of one or more specific events. Faulty Mode S DAPs data should be recorded and analyzed. Problems may be found during the routine analysis of application data. Any problem should be documented and reported to the DAPs WG.

After a problem has been found, the finder can attempt to resolve it with the appropriate party and report the solution to the DAPs WG. The problem and solution will be distributed to the DAPs WG members. If the problem has not been resolved, the problem should be reported to the DAPs WG, and members will be encouraged to resolve the problem. In many cases, a Mode S DAPs problem will be systematic across a particular aircraft or avionics configuration. Engagement with, and correction by the manufacturer may be required.

The mode S DAPs problem should be reported with the form as shown in Table 6-1.

Table 6-1 Mode S DAPs Problem Report Form

PRS#			
Start Time/Date UTC		**End Time/Date UTC**	
Registration		**Aircraft ID**	
Flight ID		**ICAO Aircraft Address**	
Aircraft Type			
Flight Sector/ Location			
ATS Unit			
Description / additional information			
Originator		**Originator Reference number**	
Organization			

PRS#: A unique identification number assigned by the PRS Administrator to this problem report. Organizations writing problem reports are encouraged to maintain their internal list of these problems for tracking purposes. Once the problems have been reported to the PRS and incorporated in the database, a number will be assigned by the PRS and used for tracking by the SURICG.

Start Time/Date UTC: UTC time/date when the event started.

End Time/Date UTC: UTC time/date when the event ended.

Registration: Registration number (tail number) of the aircraft involved.

Aircraft ID: Coded equivalent of call sign as entered in FPL Item 7.

Flight ID: The Flight ID/Flight Number downlinked from the aircraft.

ICAO Aircraft Address: Unique aircraft address expressed in Hexadecimal form.

Aircraft Type:	The aircraft model involved. For the aircraft type designators please refer to ICAO Doc 8643.
Flight Sector/Location:	The departure airport and destination airport for the sector being flown by the aircraft involved in the event. For the airport indicators please refer to ICAO Doc 7910 or related AIP. Or if more descriptive, give the location of the aircraft during the event.
ATS Unit:	ICAO identifier of the ATC center or tower controlling the aircraft at the time of the event.
Originator:	Point of contact at the originating organization for this report (usually the author).
Organization:	The name of the organization (airline, ATS provider or communications service provider) that created the report.
Description:	This should provide as complete a description of the situation leading up to the problem as is possible. Where the organization reporting the problem is not able to provide all the information (e.g. the controller may not know everything that happens on the aircraft), it would be helpful if they would coordinate with the other parties to obtain the necessary information. The description should include: a) A complete description of the problem that is being reported b) The route contained in the FMS and flight plan c) Any flight deck indications d) Any indications provided to the controller when the problem occurred e) Any additional information that the originator of the problem report considers might be helpful but is not included on the list above If necessary, to contain all the information, additional pages may be added. If the originator considers it might be helpful, diagrams and other additional information (such as printouts of message logs) may be appended to the report.

6.4.3 Example of Mode S DAPs Problem

Through monitoring, it has been reported that erroneous DAPs data have been observed due to failure or improper setting/installation of Mode S equipment. A Working Paper of the ICAO Surveillance Panel Working Group (WP ASP12-20) has indicated that a lot of incorrect, outdated and even erroneous data and parameters are present for DAPs data. The errors and/or miss-matches can be frequent, including:

a) The ACID is not always correct (erroneous)

b) The Selected Altitude is not correct or is not updated (For example Selected Altitude data should be provided by the MCP/FCU instead of the FMS as the FMS data is usually incorrect).

c) Mode S DAPs data does not correspond to the content of the requested register (BDS swap).

6.5 Application Analysis

During the Operation of Mode S DAPs application, the analysis is necessary to ensure that the system continues to meet or exceed its performance, safety and interoperability requirements. To analyze the Mode S DAPs applications, routine data should be recorded.

6.5.1 Data Recording

It is recommended that ATS providers and communication service providers retain the records defined below for at least 30 days to allow for accident/incident investigation processes. These records should be made available on request to the relevant State safety authority. Where data is sought from an adjacent State, the usual State to State channels should be used.

Where possible these recordings shall be in a form that permits a replay of the situation and identification of the messages that were received by the ATS system. Data exchange across borders may not be possible due to different Radar or ATM message formats or to State regulatory issues.

Not only the data from ground equipment, but also the data from aircraft equipment should be recorded. By analyzing the recorded data, the exact reason for the failures can be found.

6.5.2 Local Data Collection

ATS providers and communication service providers should identify and record Mode S DAPs system component failures that have the potential to negatively impact the safety of controlled flights or compromise service continuity.

6.5.3 Avionics Problem Identification and Correction

ATS providers should develop systems or procedures to:

a) detect Mode S DAPs avionics anomalies and faults

b) advise the regulators and where appropriate the aircraft operators on the detected Mode S DAPs avionics anomalies and faults

c) devise mechanisms and procedures to address identified faults

Regulators should ensure that appropriate corrective actions are taken to address identified faults.

An example of Mode S DAPs analysis is taken in Appendix 1.

6.6 Identified Issues

Several identified issues had already been recognized during the implementation of the Mode S DAPs data application in the ATM automation system. Some of them even disrupted the operation of ATC services. Thus, it is necessary to ensure the reliability of DAPs for utilization for ATC operation. This section will present some issues for helping to figure them out.

Based on the experience gained from States, the common Mode S DAPs problems are summarized under different categories in Appendix 2. It is noted that many cases of the wrong DAPs found in Mode S implementation were because of the aircraft avionics capability. Some issues resulted form human factors. Experiences showed that it was important to keep close coordination with airlines to promote the DAPs application. Airlines should be informed of the issues in time and to check their aircraft Mode S transponders promptly. At the same time, airlines need to improve their working procedures including ensuring they file flight plans correctly.

7. REGULATIONS AND PROCEDURES

Mode S DAPs involve the transmission of specific data from aircraft. These data messages can be interrogated by the ground equipment called Mode S interrogator. ATM uses the data to show the more precise and integrated situation of the surveillance aircraft. The following procedures relate to the use of Mode S DAPs data in ATS ground surveillance applications.

The implementation of the Mode S DAPs system will support the provision of high-performance surveillance, enhancing flight safety, improving the controller efficiency and reducing the workload of both the controller and pilot.

7.1 Mandating Mode S DAPs

a) Depending on the type of operations that States are going to conduct, States will have to consider whether there is a need to publish mandates. Some operations will require all aircraft within airspace to be suitably equipped while others can still work well on a ‘best equipped best served’ basis.

b) Use of Multilateration on airport surface is an example of an operation where it is recommended for all aircraft to be equipped with Mode S transponders. Another example is the conspicuity code environment, where Flight Identification may be used as the prime means to couple flight plans, allowing ANSPs to overcome the shortage of Mode A codes. Equipage mandates would be necessary for such operations.

c) With appropriate software, ATM automation systems can use Mode S DAPs to provide additional information to controllers, enabling a reduction in controller workload and the enhancement of Safety Net systems. Equipage mandates are not necessary, but consideration of the nature of the services required and/or a cost-benefit study, may warrant such mandates.

d) As of May 2018, examples of States which use Mode S DAPs without publishing mandates are Australia[1], New Zealand and Singapore. Examples of States with published mandates for Mode S DAPs are France, Germany and the United Kingdom.

e) In publishing mandate/regulations, States should:

1) Define the standards applicable to the State.

   i. E.g. *Joint Aviation Authorities (JAA) Temporary Guidance Leaflets (TGL) 13 Revision 1* for Elementary Surveillance in version 0 and version 1 transponders; or
   ii. E.g. *European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 20-13* for Enhanced Surveillance in version 0 and version 1 transponders; or
   iii. E.g. *Elementary Surveillance (ELS) requirements stated in European Aviation Safety Agency (EASA) CS-ACNS-Subpart D, Section 2 (i.e. CS ACNS.D.ELS)* for Elementary Surveillance in version 2 transponder; or

   iv. E.g. *Enhanced Surveillance (EHS) requirements stated in European Aviation Safety Agency (EASA) CS-ACNS-Subpart D, Section 3 (i.e. CS ACNS.D.EHS)* for Enhanced Surveillance in Version 2 transponder

   v. E.g. *Mode S level 2* if the requirement is simply for Airport Surface Multilateration.

2) Define the airspace affected by the regulations

[1] **Australia has a mandate for Mode S transponders at selected airports utilizing Multilateration for surface surveillance, but no widespread mandates for airborne DAPs usage**

i. E.g. *Within the [FIR Authority] Flight Information Region above Flight Level XXX*

3) Define the category of aircraft that the regulation applies to

   i. E.g. *Aircraft with a maximum certified take-off mass exceeding 5,700 kg or having a maximum cruising true airspeed capability greater than 250 kt*; or
   ii. E.g. *All IFR aircraft*

4) Define the timing of the regulations allowing sufficient time for operators to equip.

   i. E.g. *With effect from 1 Jan 2020*.

7.2 Avionics

7.2.1 Mode S Transponder Capabilities

a) The various levels of capabilities for Mode S Transponders are described in subsequent paragraphs. The state should select the capability as required by its operations.

b) According to ICAO Annex 10, Vol. 4, Mode S transponders shall conform to one of five levels of capability as follows:

   1) Level 1 is the basic transponder. Level 1 permits surveillance based on Mode A/C as well as on Mode S. With a Mode S aircraft address, it comprises the minimum features for compatible operation with Mode S interrogators. It has no datalink capability and will not be used by international air traffic.
   2) Level 2 has the same capabilities as Level 1 and permits standard length datalink communication from ground to air and air to ground. It includes automatic aircraft identification reporting. This is the minimum level permitted for international flights. Data parity with overlay control (ICAO Annex 10, Vol. 4, 3.1.2.6.11.2.5) for equipment certified on or after 1 January 2020.
   3) Level 3 has the capabilities as level 2 and also those prescribed for ground-to-air ELM communications.
   4) Level 4 has the capabilities as level 3 and also those prescribed for air-to-ground ELM communications.
   5) Level 5 has the capabilities as level 4 and also those prescribed for enhanced Comm-B and ELM communications.

c) Other than the various levels, transponders also can have the following features:

   1) Extended squitter - transponders that shall have the capabilities of level 2, 3, 4 ,or 5 and those prescribed for extended squitter operation.
   2) SI Capability - Transponders with the ability to process SI codes shall have the capabilities of level 2, 3, 4 ,or 5 and those prescribed for SI code operation.
   3) Data flash Application – transponders that implement the data flash mode.
   4) Hijack Mode Capability – transponders that support the Hijack Mode and have the capabilities of level 2, 3, 4, or 5.
   5) ACAS Compatibility –transponders compatible with ACAS.
   6) Antenna Diversity – in aircraft with transponder using two antennas, receivers and transmitting channels.
   7) According to ED-73E, Elementary Surveillance – elementary surveillance transponders will require at least a level 2 transponder and have the following capabilities:

i. Flight status reporting;
ii. Barometric pressure altitude reporting
iii. Transponder capability (CA)
iv. II and SI code capable
v. Declaration of capability (BDS code 1,0)
vi. Common usage GICB capability report (BDS code 1,7)
vii. Mode S specific services capability (BDS code 1,8 to BDS code 1,C)
viii. Flight identification (BDS code 2,0)
ix. ACAS Active Resolution Advisory (BDS code 3,0) if equipped with ACAS II
x. Aircraft register (BDS code 2,1) – optional

8) According to ED-73E, Enhanced Surveillance – enhanced surveillance transponders have the capabilities of elementary surveillance transponders, plus the capability to provide the following DAPs:

i. Magnetic Heading (BDS code 6,0)
ii. Indicated Airspeed and/or Mach No. (BDS code 6,0)
iii. Vertical Rate (climb/descend) (BDS code 6,0)
iv. True Airspeed (provided if Track Angle Rate is not available) (BDS code 6,0)
v. MCP/FCU Selected Altitude (BDS code 4,0)
vi. Ground Speed (BDS code 5,0)
vii. Roll Angle (BDS code 5,0)
viii. Track Angle Rate (if available) (BDS code 5,0)
ix. True Track Angle (BDS code 5,0)
x. Barometric Pressure Setting (BDS code 4,0)

7.2.2 Mode S Transponder Mandate

During the 31st APANPIRG meeting, the following Conclusion regarding the fitment of Mode S equipage was adopted, States/Administrations may consider the following conclusion when considering the publishing of Mode S transponder mandate.

<table>
<tr><td colspan="2">Conclusion APANPIRG/31/14 (CNS SG/24/13 (SURICG/5/3(DAPS WG3/1))) - Mode S Forward Fit Equipage in APAC Region</td></tr>
<tr><td>What: Regarding fitment of Mode S equipage,
That, States/Administrations in APAC Region be strongly encouraged to mandate that registered aircraft with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots, with a date of manufacture on or after 1 January 2022 be equipped with Mode S avionics compliant with Enhanced Surveillance (EHS).</td><td>Expected impact:
☐ Political / Global
☐ Inter-regional
☒ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: Considering that a number of DAPs applications will require EHS and that it’s easy for new aircraft to be equipped with EHS. Retrofitting existing airframes with EHS will need further deliberation under the challenging pandemic situation.</td><td>Follow-up: ☒Required from States</td></tr>
<tr><td>When: 16-Dec-20</td><td>Status: Adopted by PIRG</td></tr>
</table>

Who: ☒Sub groups ☒APAC States ☒ICAO APAC RO ☒APANPIRG ☐ICAO HQ ☒Other: SURICG

7.2.3 Transition Guidelines

a) Equipage of aircraft will be achieved over a period of time. Not all aircraft will be equipped with the necessary capability. A transition plan is required to accommodate varying degrees of aircraft equipment compliance.

b) As part of the formulation for a transition plan, States should assess the impact of having aircraft that are not suitably equipped within the affected airspace, to enable the implementation of suitable mitigating measures. States should also collect statistics on the readiness of the aircraft within the affected airspace.

c) For different operations, the mitigation measures in the transition plan could be different. For example, if the operation is just to use the Mode S DAPs to provide useful information to the controllers, the impact of having unequipped aircraft is minor. Mitigating measures could be as simple as making the controllers aware that not all aircraft are able to provide the information. On the other hand, where mode S is mandated for airport surface Multilateration, mitigating measures for having unequipped aircraft may include having special procedures for non-equipped aircraft or the deployment of a surface movement radar.

7.2.4 Mode S Transponder Working on the Ground

Table 7-1 summarizes the requirements to inhibit or not inhibit replies from aircraft on the ground.

Table 7-1 The Requirements of Transponders on Ground

Type of interrogations	**Transponder reply**
Mode A/C	Should be inhibited
Mode A/C/S All Call	Shall always be inhibited
Mode S only All Call (UF =11)	Shall always be inhibited
Mode S (Roll call UF=0,4,5,16,20,21,24)	Shall not be inhibited
Acquisition Squitter (Short Squitter)	Shall be inhibited if surface type of extended squitter is transmitted
Extended Squitter (Long Squitter)	Shall not be inhibited

[Information obtained from Eurocontrol's Clarification Mode S Transponder in an Airport/A-SMGCS Environment Ed 1.1 dated 3 May 2005]

a) Replies to Mode A/C/S all call and Mode S only all call interrogations shall always be inhibited when the aircraft declares the on the ground state. It shall not be possible to inhibit replies to discretely addressed Mode S interrogations regardless of whether the aircraft is airborne or on the ground.

b) Mode A/C replies should be inhibited (i.e. Mode A/C transponder set to standby) when the aircraft is on the ground to prevent interference when in close proximity to an interrogator or other aircraft. Mode S discretely addressed interrogations do not give rise to such interference. An exception on the recommendation to inhibit Mode A/C replies will be at airports having Multilateration systems working with Mode A/C.

c) Mode S transponders shall be set to the correct mode according to its flight status (i.e. airborne mode when it's in the air and ground mode when on the ground). When an aircraft is in ground mode, replies to all call are inhibited. It is recommended that aircraft provide means to determine the on-the-ground state automatically and provide that information to the transponder.

7.3 Mode S Interrogator

7.3.1 Working Principles

The Mode S interrogator transmits interrogation to elicit replies for detection of Mode S transponders and more information from the aircraft. The use of a unique ICAO 24-bit aircraft address and provision of all the required aircraft data in one reply will reduce interrogation rates.

Each aircraft can be interrogated selectively, needing only one or two 'hits' per aircraft per scan and minimizing interference problems associated with SSR Mode A/C.

The operation of a Mode S interrogator will not interfere with the SSR performance of any aircraft equipped with a Mode A/C transponder.

A Mode S interrogator is capable of performing the conventional surveillance function with Mode A/C transponders.

7.3.2 Interrogator Codes

The Mode S system requires each interrogator to have an IC, which can be carried within the uplink and downlink transmissions. The 4-bit IC uplink field in UF11 shall contain either 4-bit II code or the lower 4 bits of the 6-bit SI codes. It is recommended that whenever possible an interrogator should operate using a single interrogator code.

The II codes shall be assigned to interrogators in the range from 0 to 15. The II code value of 0 shall only be used for supplementary acquisition. The SI codes shall be assigned to interrogators in the range from 1 to 63. The SI code value of 0 shall not be used.

The assignment of interrogator II or SI codes, where necessary in areas of overlapping coverage, across international boundaries of flight information regions, shall be the subject of regional air navigation agreements. The ICAO Asia Pacific Regional Office maintains a register of II codes used – where States have provided this information to the office. States are encouraged to provide this information to the Regional Office and update it when changes are made.

7.3.3 Mode Interlace Pattern

The particular air traffic and environment of each interrogator will influence the selection of suitable interrogation periods, interrogation repeat frequency, MIP and Probability of Reply.

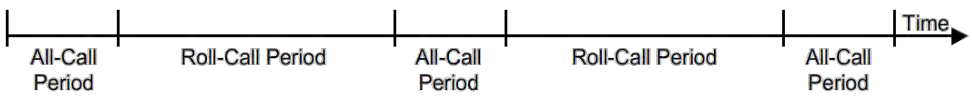

Figure.7-1 The Typical MIP

The repetition frequency and duration of the All-Call period is a local implementation issue (the stated ICAO maximum is 250Hz). The exact duration of either period will depend on the characteristics of the system such as the antenna revolution rate, the beam-width and the maximum range. There will normally be several all-call periods (and hence roll-call periods as one will always follow the other) available to interrogate all targets in range during one revolution.

There is a careful balance between the reliable acquisition of all targets and the potential of flooding the RF environment with unwanted replies to acquisition interrogations. It is necessary to choose an appropriate Mode Interlace Pattern to manage the acquisition activities to ensure minimal interference. The default objective is to define a MIP which effectively detects and performs surveillance on classical SSR Mode A/C aircraft using Mode A/C interrogations which also detects and acquires Mode S aircraft using Mode S interrogations. The MIP is constructed in order to separate Mode A/C and Mode S all-calls from Mode S selective (roll-call) activity. MIP defines the sequences of all-call interrogation types that might be made during cycles of all-call periods. Every interrogator is likely to have different needs and hence different ways of operating.

China presented an IP about the Mode S Parameter Set during the 3rd meeting of DAPs WG. For detailed information please refer to Appendix 4.

7.3.4 DAPs Extraction by GICB Protocol

The GICB procedure is initiated by a Mode S interrogator for eliciting the Mode S DAPs containing aircraft derived data from a Mode S aircraft installation.

The GICB protocol allows for the immediate transfer of data required by the ground and the extraction of information stored in the Mode S transponder. This information (if available) is contained in the reply to an interrogation specifying the address (BDS code) of the storage location containing that information.

The interrogation with specific BDS can elicit the corresponding Comm-B data where contained in Mode S transponder's registers. The Mode S DAPs can be implemented in two stages: ELS and EHS.

The first processing step for any Mode S data link application is to obtain the transponder CA value from the aircraft. The 3-bit CA field is found in the "Mode S All-Call Reply" (DF=11) and the "Extended Squitter" (DF=17) downlinks. If CA=0, then this transponder is surveillance-only and supports no data link functions at all. If CA⩾4 indicates that the Mode S transponder is fully capable of at least 56-bit short uplink and downlink message transfer. These Mode S transponders may support the ELS, EHS requirements. The values of CA= 1, 2, 3 are reserved.

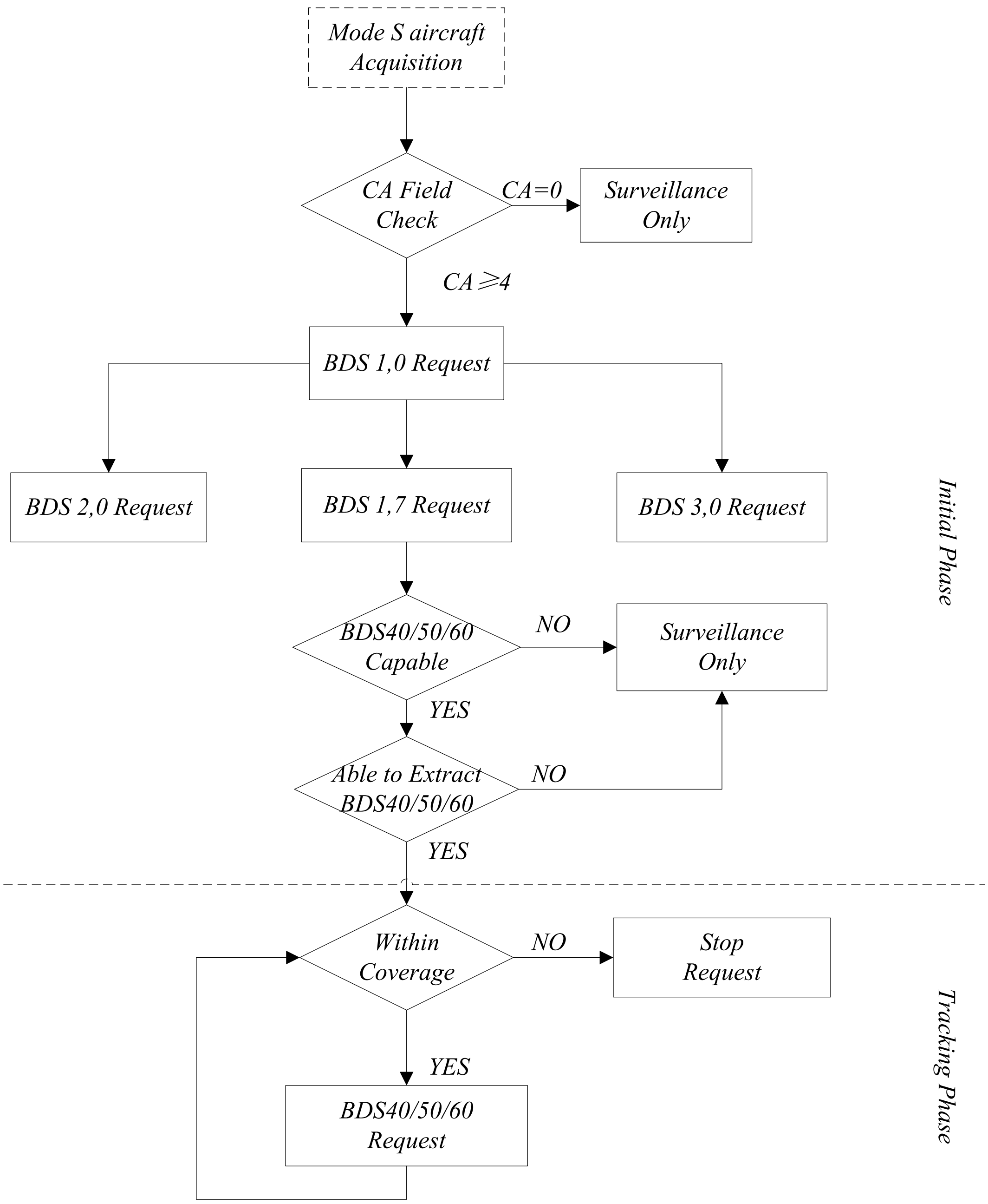

Figure.7-2 The Typical Procedure of DAPs Extraction

Given that the Mode S transponder's CA value is 4 or greater, the second processing step for any Mode S data link application is to extract the transponder's Mode S data link capability report register BDS code 1,0. Bits in this register indicate the support of such Mode S data link functions as aircraft identification (register BDS code 2,0), ACAS (register BDS code 3,0), common-usage capability (register BDS code 1,7) etc. The Mode S-Specific services capability bit in register BDS code 1,0 indicates whether the avionics installation supports further data link functions. If this bit is set, the Mode S data link application would next extract the common-usage capability register BDS code 1,7. All of the registers involved with the EHS application have bit flags assigned in this register BDS code 1,7. If the bit flag is set, it indicates that the corresponding register has been updated in a timely manner and contains valid data which can be extracted by the interrogator. The processing protocol is sufficient initialization for basic data link applications such as ELS, EHS since all their status and configuration information is available from register BDS code 1,0 and register BDS code 1,7.

So, the Mode S interrogator should transmit the selective interrogation to elicit the Mode S transponder reply with the specific formats and Comm-B data contained in the corresponding registers.

Normally, the more Comm-B data requested by the Mode S interrogator, the more information can be extracted from the aircraft transponder registers. It will also help the ATC controller get the aircraft's flight status and flight intention. However, there should be some necessary limitations for the Comm-B data request to avoid the phenomenon of Comm-B data discontinuity because of the limited Roll-Call interrogation duration.

It is suggested that the number, periodicity and priority of BDS data extraction rule be reasonably and effectively implemented according to the requirements and the number of aircraft in the airspace. The scientific strategy can ensure the ATC controller gets Comm-B data timely and effectively.

7.3.5 DAPs Extraction by AICB Protocol

The AICB procedure is initiated by a Mode S transponder for transmitting a single Comm-B segment from the aircraft installation.

Any changes in the contents of ACAS (register BDS code 3,0) triggers a downlink message via the air-initiated Comm-B broadcast protocol including the updated register contents.

An AICB sequence shall start upon the acceptance of a message intended for delivery to the ground sensor. After receipt of this message, the transponder shall set a valid downlink request code of surveillance or Comm-B reply. On receipt of this message with a valid downlink request code, the interrogator could start to extract the message.

AICB messages are announced by the transponder and are transmitted in a subsequent reply only after authorization by the interrogator. AICB messages are announced to all interrogators and can be extracted by any interrogator. The Mode S data link application should update the aircraft’s “state” values with the new ones. The changed state might result in discontinuance (or reinstatement) of certain Mode S data link functions. Mode S transponder AICB broadcast messages are held active in the transponder for 18 seconds after the triggering event. Any Mode S sensor can extract the broadcast information.

7.3.6 DAPs Extraction by Comm-B Broadcast

A Comm-B broadcast is a message directed to all active interrogators in view. Messages are available for 18 seconds unless a waiting AICB interrupts the cycle. Interrogators have no means to cancel the Comm-B broadcast.

Currently, only registers of datalink capability report (register BDS code 1,0) and aircraft identification (register BDS code 2,0) make use of the Comm-B Broadcast.

7.4 ATM Automation System

7.4.1 Elementary Surveillance

For the Elementary Surveillance, the following parameters of aircraft can be beneficial to the ATM automation system:

a) ICAO 24-bit Aircraft Address/Aircraft Identification

1) The ATM automation system should collect the real aircraft address/aircraft identification from the received message, and the aircraft address/aircraft identification can be shown on the control HMI to identify the aircraft.

2) The ATM automation system can use the aircraft address/aircraft identification to correlate an aircraft's track with the flight plan, so the use of aircraft address/aircraft identity can alleviate the shortage of Mode 3/A code. Correlation between track and flight plans is normally based on either the 24-bit aircraft address, aircraft identification, or the Mode 3/A code. The correlation will depend on their weights and priority.

3) The ATM automation system can also utilize the aircraft address/aircraft identification to improve the tracking function.

4) The ATM automation system could provide DUPE warning between aircrafts which have the same ICAO 24-bit aircraft address, same aircraft identification or the same Mode 3/A code.

b) Transponder Capability Report

The ATM automation system can collect the datalink capability of the transponder from the received message and show the information to the controller. The controller can estimate whether the aircraft with this transponder meets the requirement in the airspace

c) Altitude reporting in 25ft interval

The ATM automation system can collect aircraft altitude reporting in 25ft increments and provides valuable improvements to the quality of safety nets. The improvements should reduce the number of nuisance alerts and enhance the integrity of separation assurance.

d) Flight status (airborne/on the ground)

The ATM automation system can collect the flight status of the aircraft. Whether the aircraft is airborne or on the ground can be shown in the system to improve the situational awareness of the controller. Also, the flight status can be used to filter the aircraft on the ground in the system if necessary.

e) ACAS Resolution Advisory Report

Some of the ATM automation system can collect the ACAS Resolution Advisory Report and the information can be shown in the system to improve situational awareness of the controller. On receipt of ACAS Resolution Advisory notification, a prominent notification is displayed in a field that may be acknowledged. The indication is removed when the ACAS RA is resolved.

Note: The display of ACAS Resolution Advisory Report in ATM automation system can be turn on or turn off by user, and it is not recommended by IFATCA. The user is suggested to do the relevant safety evaluation before applying this function.

7.4.2 Enhanced Surveillance

For the Enhanced Surveillance, the following parameters of aircraft can be beneficial to the ATM automation system:

a) Selected Altitude

1) The ATM automation system can collect the selected altitude of the aircraft and show the information to the controller to improve the situational awareness of the controller.

2) The ATM automation system can generate aSFL Mismatch Alarm when the SFL chosen by the crew does not match the cleared altitude given by the controller (CFL), alerting the

controller to take appropriate action to remedy the issue. A SFL Mismatch Alarm shall be presented to the responsible controller as an indication in the coupled surveillance track label and in the associated flight strip.

3) The ATM automation system can also utilize the SFL to improve the accuracy of the safety net.

In MTCD function, the ATM automation system can use the selected altitude as the target climbing/descending altitude in the flight look-ahead time, and calculate the possibility of conflict with the predicted flight trajectories of other flights in the airspace through trajectory prediction. Calculations involving SFL could be more accurate, and improve the performance of MTCD.

In the MSAW function, the ATM automation system generally provides MSAW warning by using track data (heading and rate of climb/descent and mode c). The ATMs use of CFL or SFL can enhances the MSAW algorithms use of vertical data to predict MSAW alerts and reduce the number of false alerts..

b) Barometric Pressure Setting

The ATM automation system can collect the barometric data of the aircraft and show the information to the controller. The system can provide a warning when the barometric data transmitted by the aircraft does not match the parameter of the area where the aircraft is operating.

c) Roll Angle, Track Angle Rate, True Track Angle, Ground Speed, Magnetic Heading, True Airspeed

1) The ATM automation system can collect these parameters and may allow the display of some of the information to the controller to improve the situational awareness of the controller. This information can be displayed in various ways (e.g., a DAP Window) as offline defined, according to the requirement of the controllers. Display of some parameters, provides a clearer picture to the controllers generating a reduction in radio calls with the pilot, so the R/T usage between the controller and individual aircraft under service is reduced.
2) The system can make use of DAPs kinematics parameters for consistency checking, and perform a more precise tracking function.
3) The system can utilize the kinematics information of the aircraft to improve the accuracy of safety net functions, (e.g., Short-Term Conflict Alert (STCA)), through the provision of more accurate aircraft tracks.
4) The system may use True track angle, Magnetic Heading, True Airspeed and Ground Speed to calculate a wind direction and speed of a specific area, which will enable the updating of forecast winds and improve trajectory modeling in the system. The system may also show the wind information to the controller to improve the situational awareness of the controller.

d) Barometric Altitude Rate, Inertial Vertical Velocity

The ATM automation system can collect the vertical rate data of the aircraft to improve the precision of the compute altitude and the accuracy of the related alert. The system can make use of the data to realize an optimized CFL protection in STCA and MSAW analysis function.

e) Indicated Air Speed/Mach Number

The ATM automation system can acquire indicated airspeed/Mach number of the aircraft, allow ATC to monitor the aircrew compliance with the controller’s instructions, and if required provide a warning to the controller when there is a mismatch.

7.5 Flight Planning

7.5.1 ICAO Flight Plan Item 7 - Aircraft Identification

ACID must be accurately recorded in item 7 of the ICAO Flight Plan form as per the following instructions:

Aircraft Identification, not exceeding 7 alphanumeric characters and without hyphens or symbols is to be entered both in item 7 of the flight plan and replicated exactly when set in the aircraft (for transmission as Flight ID) as follows:

Either,

a) The ICAO designator for the aircraft operating agency followed by the flight identification (e.g. KLM511, NGA213, JTR25), when in radiotelephony the call sign to be used by the aircraft will consist of the ICAO telephony designator for the operating agency followed by the flight identification (e.g. KLM 511, NIGERIA213, JESTER25).

Or,

b) The nationality or common mark registration marking of the aircraft (e.g. EIAKO, 4XBCD, N2567GA), when:
    1) in radiotelephony the callsign used by the aircraft will consist of this identification alone (e.g. CGAJS), or preceded by the ICAO telephony designator for the operating agency (e.g. BLIZZARD CGAJS),
    2) the aircraft is not equipped with a radio.

Note 1: No zeros, hyphens, dashes or spaces are to be added when the Aircraft Identification consists of less than 7 characters.

Note 2: Appendix 2 to ICAO DOC4444 (PANS-ATM 16th edition, 2016) refers.

Note 3: Standards for nationality, common and registration marks to be used are contained in Annex 7, section 3.

Note 4: Provisions for the use of radiotelephony call signs are contained in Annex 10, Volume II, Chapter 5. ICAO designators and telephony designators for aircraft operating agencies are contained in Doc 8585 — Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services.

7.5.2 Equipment (Surveillance Equipment /SSR Equipment)

a) ICAO Flight Plan Item 10 – Surveillance Equipment and Capabilities

When an aircraft is equipped with a Mode S Transponder, appropriate Mode S designators shall be entered in item 10 of the flight plan to indicate that the flight is capable of transmitting Mode S DAPs messages.

These are defined in ICAO DOC 4444 as follows:

‘N’ No surveillance equipment for the route to be flown is carried, or the equipment is unserviceable

SSR Mode A and C

‘A’ Mode A transponder

‘C’ Mode A and Mode C transponder

SSR Mode S

‘E’ Mode S transponder, including aircraft identification, pressure-altitude and extended squitter (ADS-B) capability

‘H’ Mode S transponder, including aircraft identification, pressure-altitude and enhanced surveillance capability

‘I’ Mode S transponder, including aircraft identification, but no pressure-altitude capability

‘L’ Mode S transponder, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability

‘P’ Mode S transponder, including pressure-altitude, but no aircraft identification capability

‘S’ Mode S transponder, including both pressure altitude and aircraft identification capability

‘X’ Mode S transponder with neither aircraft identification nor pressure-altitude capability

Note: Enhanced surveillance capability is the ability of the aircraft to down-link aircraft derived data via a Mode S transponder.

b) ICAO Flight Plan Item 18 – Other Information

Where required by the appropriate authority the ICAO AA (24 Bit Code) may be recorded in Item 18 of the ICAO flight plan, in hexadecimal format as per the following example:

CODE/7C432B

Members or states should note that use of hexadecimal code may be prone to human error and is less flexible in regard to airframe changes for a notified flight.

7.5.3 Inconsistency between Mode S Flight Planning and Surveillance Capability

Inconsistency between flight planning of Mode S and surveillance capability of an aircraft can impact ATC planning and situational awareness. States are encouraged to monitor for consistency between flight plan indicators and actual surveillance capability. Where discrepancies are identified aircraft operators should be contacted and instructed to correct flight plans, or general advice (as appropriate to the operational environment and type of flight planning problems) should be issued to aircraft operators.

Advice to Operators:

Concerning inconsistency between Mode S Flight Planning and Surveillance Capability:

a) ICAO AA (24 Bit Code) not submitted, or submitted incorrectly.

b) Mode S and surveillance capabilities indicators incorrectly.

The flight planning requirements and relevant designators for aircraft are described in local document reference or ICAO DOC 4444 Appendix 2. The capability of the aircraft transponder and ADS-B capability will typically be available in the transponder manual or the aircraft flight manual for the aircraft. If in doubt, consult the transponder manual, aircraft flight manual or the Licensed Aircraft Maintenance Engineer.

7.5.4 Setting Flight ID in Cockpits

a) Flight ID Principles

The Flight ID is the equivalent of the aircraft callsign and is used in both Mode S SSR and ADS-B technology. Up to seven characters long, it is usually set in airline aircraft by the flight crew via a cockpit interface. It enables air traffic controllers to identify an aircraft on a display and to correlate a radar or ADS-B track with the filed flight plan ACID. Flight ID is critical, so it must be entered carefully. Punching in the wrong characters can lead to ATC confusing one aircraft with another.

The Flight ID entered in the transponder exactly must match the ACID entered in the flight plan.

Intuitive correlation between an aircraft's flight identification and radio callsign enhances situational awareness and communication. Airlines typically use a three letter ICAO airline code in flight plans, NOT the two letter IATA codes.

b) Setting Flight ID

The callsign dictates the applicable option below for setting Mode S or ADS-B Flight ID:

1) The flight number using the ICAO three-letter designator for the aircraft operator if a flight number callsign is being used (e.g. QFA1 for Qantas 1, THA54 for Thai 54).
2) The nationality and registration mark (without hyphen) of the aircraft if the callsign is the full version of the registration (e.g. VHABC for international operations).
3) The registration mark alone of the aircraft if the callsign is the abbreviated version of the registration (e.g. ABC for domestic operations).
4) The designator corresponding to a particular callsign approved by the ANSP or regulator (e.g. SPTR13 for firespotter 13).
5) The designator corresponding to a particular callsign in accordance with the operations manual of the relevant recreational aircraft administrative organization (e.g. G123 for Gyroplane 123).

7.6 Contingency Plan

ANSPs should prepare appropriate contingency plans in the event of a system failure that prevents the use of Mode S DAPs.

8. TRAINING AND COMPETENCE

8.1 Introduction

Training and development play an important role in the effectiveness of organizations and to the experiences of people in work. Training on DAPs has implications in improving productivity, aviation safety and personal development. The primary goal of the training is to develop and maintain an appropriate level of trust in DAPs related module, i.e. to make ATC and ATSEP aware of the likely situations where DAPs will be effective and, more importantly, situations in which DAPs will not be so effective (e.g. sudden, unexpected maneuvers).

8.2 Training of an Air Traffic Controller (ATC) in DAPs

With the inclusion of DAPs into surveillance and ATM automation system, an ATC training plan should adopt a modular approach. This approach progressively introduces various features, functionality of the new system on one hand and allows for integration with the ATC operational procedures. Additional benefits include shorter, logical self-contained units, clear attainable goals, better evaluation of training effectiveness and simplified self-assessment.

The ANSP should develop familiarization and rating focused training to ATC prior to adoption of DAPs in Surveillance and ATM automation systems.

The ANSP should ensure that all ATC concerned are assessed as competent for the use of the relevant DAPs module.

8.3 Training of an ATSEP in DAPs

a) The ANSP should develop an ATSEP training programme that is acceptable to the ANS Regulator prior to its implementation.

b) As a minimum, the training programme should comprise three levels as described below:

   1) Level 1 (Basic training). This should comprise training on the basic Surveillance and ATM automation systems operating in the State and their impacts on the safety of aircraft operations. The ANSP should ensure every ATSEP undergoes the basic training.

   2) Level 2 (Qualification training). This should comprise training to develop knowledge and skills on Surveillance and ATM automation systems. The ANSP should ensure each ATSEP is trained in one or more domains depending on their job scope.

   3) Level 3 (Specialized training). This should comprise training on specific Surveillance and ATM automation systems installed in the State, followed by on-the-job training.

c) The ANSP should conduct a yearly review of the training plan for each ATSEP at the beginning of the year to identify any gaps in competency or changes in training requirements and priorities the type of training required for the coming year in regards of DAPs development.

d) The ANSP should keep records of individual ATSEP training, competency assessment and approval history, where applicable, and associated documents. The records should be kept at least until the Surveillance and ATM automation system of which the ATSEP was trained on is no longer in use with the ANSP.

e) The individual training records for each of ATSEP should include a training plan detailing the courses completed as well as the time-frame for attending future courses as required under his/her training plan.

8.4 Competency Assessment of an ATSEP in DAPs

a) The ANSP should develop an assessment methodology to determine the competency of an ATSEP in accordance with the competency framework developed in PANS-Training and which should be adapted to suit the local context.

b) The ANSP may select a person to be a competency assessor only if the person –

   1) is an ATSEP approved in accordance with paragraph 8.3 for the particular Surveillance and ATM automation system; and

   2) has received adequate training in the conduct of competency assessment, practical checks and oral questionings.

c) A competency assessor should not conduct a competency assessment on an ATSEP who is under the direct supervision of the competency assessor, unless the assessment is done in the presence of a second independent assessor.

d) The assessment methodology should include a process for on-going competency checking and refresher training to ensure retention of competence.

9. SPECIFIC EXAMPLES ON MODE S DAPs APPLICATION

9.1 Use of Selected Altitude

Since August 2013, Mode S data processing functions have been implemented in Chengdu ATM automation system. The system uses the select altitude data extracted from the Mode S DAPs to provide an optimized CLAM alert for controllers. The system will generate the alert when the SFL chosen by the crew does not match the cleared altitude recorded in the ATM automation system. And a time delay parameter is predefined for the response time of the flight after controllers input to the ATM automation system (typically at the time of instruction given to the pilot).

Thanks to this new kind of alert, controllers have a better awareness of the intention of the airplanes and may discover the crew's mis-operation much earlier than the traditional CLAM, and then take actions timely to avoid the potential conflict.

In April 2017, an A320 aircraft was maintaining level flight at 27600 feet with another flight flying nearby at 26600 feet. Suddenly, the crew set an error altitude 22600 feet. The ATM automation system triggered the alert immediately even before the aircraft began to descend. The controller quickly noticed the alert and informed the crew in time. The aircraft successfully stopped descend at 27400 feet.

9.2 Use of ACAS RA

With the advancement of the ASTERIX standards and DAPs application, an ATM system can handle the derived data from Aircraft, which is detected, received and transmitted through the Mode S Radar, ADS-B station, and WAM sensors . In the event that an Airborne Collision Avoidance System (ACAS) Resolution Advisory (RA), the ATM system is able to provide a visual and aural alarm warning and indicative pilot intention to the controller.

Resolution Advisory (RA) alerting function works as follows:

- A resolution advisory is present when, in the subfields I048/260, I020/260, I021/260, I021/260 or I062/380 subfield #12(ACS), the bits are set as follows:

• the first bit of the ARA field set to 1 and the RAT bit set to 0 or,

• the first bit of the ARA field set to 0, the MTE bit set to 1 and the RAT bit set to 0.

- A resolution advisory is removed when:

• the ACAS RA report subfield (I048/260, I020/260, I021/260 or I062/380 subfield #12(ACS)) contains the RAT bit set to 1, or

• An ACAS RA report is not received in the relevant Data Item of the ASTERIX report.

Besides, the Resolution Advisory Intention is populated base on the PILOT selection and according to the following table:

MTE (60)	**ARA (41)**	**42**	**43**	**44**	**45**	**46**	**47**	**RA Selection**	**RA Intention**
1	0	Any	0	Any	1	Any	Any	Descend	Positive descend (Descent

									to avoid the threat)
1	0	Any	1	Any	0	Any	Any	Climb	Positive climb (Climb to avoid the threat)
1	0	Any	0	Any	0	Any	Any	Other	Other

*NOTE1: ACAS Airborne Collision Avoidance System, applied in the EURO Aviation System, has the same meaning as TCAS abbreviated to Traffic Alert and Collision Avoidance System in the USA Aviation System

*NOTE2: The function and the matters needing attention related to ACAS Resolution Advisory Report in ATM automation system, please refer to 7.4.1 e).

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9.3 Use of Mode-S DAPs data for weather forecast

Meteorological Research Institute (MRI) and Electronic Navigation Research Institute (ENRI) conducted experiments for improving weather forecast accuracy utilizing Mode S DAPs data. In this research, estimate horizontal wind and temperature from the data in registers BDS code 5,0 and BDS code 6,0 which list below.

Table 9- DAPs information for weather forecast

Register	Name	Data Item
BDS code 5,0	Track and turn report	True Track Angle
		Ground Speed
		True Airspeed
BDS code 6,0	Heading and speed report	Magnetic Heading
		Mach Number

The temperature is the function of Mach number and True Airspeed. To estimate horizontal wind speed and direction, calculating zonal wind speed and meridional wind speed from ground speed, true airspeed, true track angle and true heading angle. The true heading angle is obtained from magnetic heading angle and magnetic declination(D2010) which is given by a quadratic equation. Then the wind and temperature as observation data were used to analyze and adjust the value of the numerical model to improve weather forecast accuracy.

The results of the experiments indicate that Mode S DAPs data have the potential to improve forecasts of rainfalls and shear-lines. For details, please refer to the IP11 presented by Japan at the Mode S DAPs/3.

9.4 Use of Barometric Pressure Setting

When the aircraft is below the transition level the pilot is required to set barometric pressure setting in altimeter to local QNH/QFE. Wrong barometric pressure setting (especially QNH higher than actual) can lead to cleared flight level deviation or more serious controlled flight into terrain, as the pilot sees higher altitude on his altimeter and the flight management system determines the lower target altitude base on barometric pressure setting and selected altitude. Every millibar of barometric pressure setting error may add 30 feet of error to altimeter and target altitude.

Constantly checking if the barometric pressure setting in DAPs is consistent with the airport's QNH can alert the controller to avoid similar situations. In Feb 2021, an aircraft was cleared to descend to 7000 feet. The pilot set the right selected altitude, but forgot to set barometric pressure setting. At that time, the airport QNH was 1013, while the crew barometric pressure setting was 1118.5. An alarm system notified the controller of this situation. The error was corrected after the controller prompted the pilot preventing a dangerous situation.

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APPENDIX 1: Mode S DAPs Analysis

a) Data Recording Configuration

Figure 1 represents an example of a configuration for data recording. The Mode S sensor sends interrogations to an individual aircraft using a unique ICAO 24-bit aircraft address. The Mode S transponder has 255 BDS Registers. Each register stores aircraft parameters data derived from FMS or other sensors. An interrogation uses GICB protocol to request a specific BDS Register data. In response to the interrogation, Mode S transponder sends a reply which contains the BDS register data.

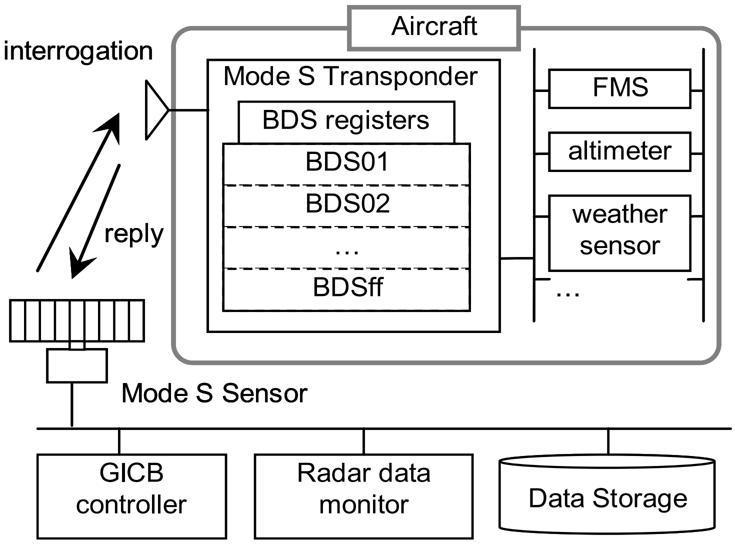

Figure1 - Example of Data Recording Configuration

b) Data Analysis

As described above section, erroneous DAPs data have been observed due to failure or improper setting/installation of Mode S avionics equipment. Bad data hinders the use of DAPs by the ATM service. To employ DAPs for ATM services, the reliability of DAPs is important. Therefore, it is necessary to analyze the recorded data to ensure reliability of the DAPs data.

If a controller finds some problem during the application of the Mode S DAPs, the ATS providers can analyze the recorded data to find the exact reason which caused the problem. If the ATS equipment has a fault which caused the problem, the ATS provider should implement a solution as soon as possible. If the ATS provider proves that the problem is caused by an avionics fault, then the problem should be reported to the appropriate party to solve the problem. The ATS providers need to devise mechanisms and procedures to address identified faults.

ATS providers should develop systems to analyze the routine recorded data. From the analyses, ATS providers can provide more information of the transponder's performance such as SI capability, datalink capability etc. The information can be used to improve the capability of the operation of Mode S DAPs equipment. By analyzing the recorded data, advice on avionics anomalies and faults, which have been detected, can be passed onto the regulators and the aircraft operators.

c) DAPs Data Validation

To ensure that Mode S DAPs are operating in conformance with the ICAO requirements, validating DAPs data is highly recommended. It has been noted that there are some drawbacks in the traditional methodology of executing tests for aircraft on the ground as follows:

1) Avionics for DAPs consist of several devices and functional blocks. They are interconnected, and the configuration is complicated.
2) Avionics and configuration differ depending on each aircraft.
3) It is difficult to cover the possible test patterns completely.
4) Ground test methodology would not detect failures or anomalies that occur after the testing.

Responding to these drawbacks, MIT Lincoln Laboratory developed and proposed a DAPs validation methodology, which monitors DAPs data received from actual flying aircraft to detect erroneous data. The MIT validation methodology is mainly categorized by two groups, static value tests and dynamic value tests.

Static value tests are executed to detect erroneous values of the bits and fields in BDS registers which do not change during a flight. Those bits and fields represent the avionics system's configuration, capability, and status information. These tests verify that those bits and fields are proper values in compliance with the ICAO regulations for DAPs applications. Table 1 shows an example of static value tests. As can be seen by the table, failed data were detected in each BDS register test. For BDS Register 20_{16}, failed data with wrong character coding were caused not due to equipment problem, but to faulty data input.

Table 1 Example of Static Value Tests

BDS Register	Test Item	Total Count		Aircraft	
		Executed	Failed	Executed	Failed
BDS code 1,0	Aircraft identification capability flag = '1'	544,980	7,183	3,615	146
BDS code 2,0	Each character conforms to ICAO 6-bit character coding	737,993	1,516	3,596	144
BDS code 4,0	Unavailable data fields are set at zero	54,248,802	1,755	3,614	4

Dynamic value tests validate the values which dynamically change according to aircraft motion, such as aircraft speed and track angle. The tests compare the DAPs values with equivalent data like radar-measured positions. If the difference between DAPs values and radar-derived parameters exceeds the acceptability threshold, the DAPs value is accounted as an error. Figure 2 represents an example of dynamic value tests. This figure indicates that ground speed differences between DAPs data and radar-derived data fall inside the threshold range.

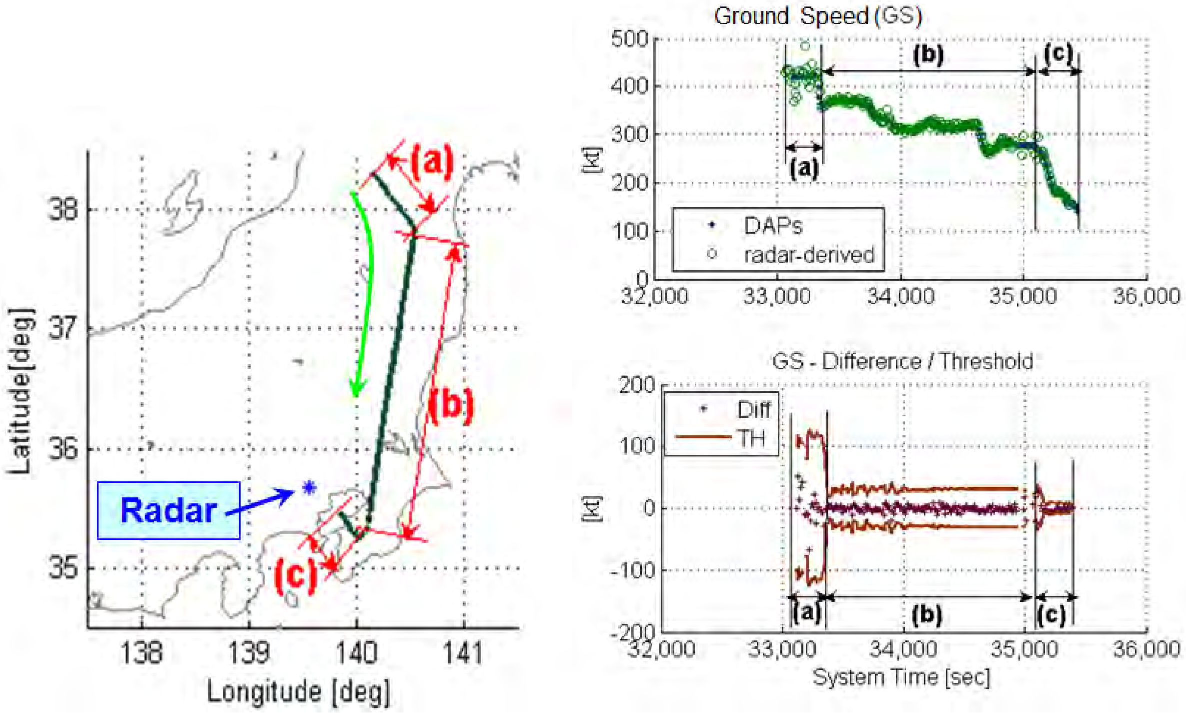

Figure 2 - Example of Dynamic Value Tests

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APPENDIX 2: LIST OF IDENTIFIED ISSUES

Ref.	Issue	Cause	Safety Implications to ATC (Yes / No)	Recommendations
1.	Wrong ground bits in DAPs led to the track decoupling from the flight plan	Through joint investigation with the airlines, it found that parts of the aircraft A were exchanged with another aircraft B for test. The malfunction part was discovered when the wrong ground bits data was found coming from the aircraft B.	**Yes** The wrong ground bits in DAPs could make ATM automation system display track decoupled with flight plan	
2.	Wrong aircraft identification	Many cases of wrong aircraft identification were found at the beginning of mode S operation. All related data collected and sent to the relevant airlines by the management department. Through joint investigation with the airlines, it was found that the issue is normally due to pilot's error.	**Yes** Wrong aircraft identification could lead to wrong flight plan coupling.	Through the joint efforts of ATMB and the airlines, the aircraft identification data became more and more accurate.
3.	Wrong Barometric Pressure	Barometric Pressure, such as BARO or QNH, is available in Mode S BDS code 4,0. Initial testing found that data above the transition level for some aircraft types would not be useful due to a mismatch between what the crew set in the cockpit, and what the aircraft Downlinked.	Yes There will display a wrong Barometric Pressure with aircraft in ATM automation system.	EASA Safety Information Bulletin SIB-2016-05R2 ("Incorrect Downlink Barometric Pressure Settings") covers this issue.
4.	Different processing between Mode A/C and Mode S Altitude	Currently, the altitude accuracy of Mode A/C radar is 100ft, while that of Mode S radar is 25ft. The altitude tracking, and display mechanism of ATM automation systems could be received both precisions altitude data.	**Yes** In Mode S radar and Mode, A/C radar overlapped area, the ATM automation systems might display an altitude jumping.	The altitude tracking, and display mechanism of ATM automation systems need to be optimized to avoid altitude jumping.

5.	Mode S interrogators request the aircraft transponder registers too frequently in busy airspace	If Mode S interrogators request the aircraft transponder registers too frequently in busy airspace, it may appear that the transponder registers information cannot complete the whole transmission process. The BDS parameters requesting rule needs to be set by the Mode S interrogator reasonably.	**Yes** ATM automation system would display track delay or intermittent interruption of radar data.	The data transmission rate of Mode S radar to feed ATM automation system needs to be selected reasonably to meet the requirements of ATC operations in busy airspace to prevent track delay or intermittent interruption of radar data.
6.	Mode S DAPs data does not correspond to the content of the requested register	It has been noted that from time to time Mode S DAPs data does not correspond to the content of the requested register. For example, the content of BDS code 5,0 is received when extracting BDS code 4,0. This phenomenon is called “BDS swap”. Table 1 represents an example data of BDS swap. The table shows the data of BDS code 0,5/4,0/5,0 data downlink from an aircraft in three sequential scans. As can be seen by the table, BDS swap occurred at 08:05:45.	**Yes** Wrong information could display to controller.	Different options can be implemented to decrease the impact of such as: 1. limit the number of radars extracting aircraft registers 2. implement specific filters in radar or in the surveillance data processing to discard the erroneous data (e.g. when two different registers are received with the same content they are both discarded)

7.	Duplicated aircraft address	One case was related to a local airline, wrong spare parts of the airplane were installed by mistake during maintenance. The airline replaced the spare parts after being informed. Another case was military aircraft. Another reason has been observed that in many cases the 24-bit aircraft address transmitted by the aircraft does not match its nationality (i.e. its State of Registry's block) or is otherwise incorrectly configured in the transponder. Care needs to be taken to ensure that the registration and the 24- bit address of every aircraft are processed and assigned simultaneously by the regulatory authority, and reporting mechanisms are in place to rectify incorrect configurations.	**Yes** The possible consequences are as follows: 1. An aircraft may be locked out in error, if it is the same beam. This may result in a new aircraft not being detected when it enters Mode S radar coverage. 2. Possible track label swap for crossing aircraft, this may result in incorrect labeling of an aircraft on the Radar screen. 3. In the technical operation of Mode S Elementary surveillance, duplicated address may result in the possible loss of a track when the two aircraft are crossing due to the interrogation scheduling within the ground station.	According to Annex 10, the aviation authority of each State is responsible for assigning 24-bit addresses to all aircraft in its registry using the block allocated by ICAO to that State. The duplicate address should be detected and reported. Without duplicate address detection, if an aircraft enters the range of the Mode S SSR with the same ICAO 24-bit address as that of an existing target, the information of the new aircraft could be erroneously associated with the existing target. Once the Mode S DAPs System detect more than one aircraft is transmitting the same ICAO 24-address, it will initiate a duplicate address report and a duplicate address condition shall be declared, and when receive new information of this address, the system should associate the information by ID or position but not the address.
8.	incorrect aircraft address in flight plan	Although the overwhelming majority aircrafts are equipped with Mode S transponders, many flight plans are not filed with the correct aircraft address in	**Yes** This affects the function of aircraft address correlation in ATM automation system.	

		item 18.		
9.	incorrect wind speed and direction	Aircrew round the system output figures from Spot Wind data was the main reason for variations by crew response. e.g. Recorded wind 283/42kts, crew response 280/40kts.	**No**	
10.	empty ACAS RA message	ASTERIX message "I048/260, ACAS Resolution Advisory Report" indicates that airplane is in ACAS RA condition. In some cases, all zero I048/260 reports are received in the ATM automation system through Mode S radar.	**Yes** ATM automation system may generate false ACAS alarm from Empty RA message.	ACAS message handling feature at ATM system must be checked on at its installation stage following the ACAS message flow
11.	erroneous SFL information	It is noticed ATM automation system could receive erroneous SFL information due to the BDS swap problem and other reasons.	**Yes** ATM automation system may generate false SFL mismatch alarm due to the erroneous SFL information.	ATM automation system could use multiple data sources to check the SFL data.
12.	Incorrect ACAS RA information	Many cases of incorrect ACAS RA information were found at the Mode S operation. After analysis the incorrect ACAS RA data，the reason is so called "BDS Swap" and only the old type of Mode S radar has the "BDS Swap" problem.	Yes Wrong information could display to controller.	Short term solution: Reject data (BDS content and/or reply) in case of difference between UF and DF. Reject BDS content (BDS 1,0; 2,0 and 3,0) in case of first byte error. Medium /long term solution: "Overlay" function is introduced in the fifth edition of Volume IV of ICAO document annex 10. the DP (data parity) field is designed to replace the AP field to check

				the BDS register number in the downlink DF20 / 21. It aims to solve BDS swap problem from the source.

Table 1 Example Data of BDS Swap

BDS Register	**Time of Scan**		
	08:05:35	**08:05:45 (BDS swap occurred)**	**08:05:55**
BDS code 0,5	605f80c056966f	a3280030a40000	605f845303ce8d
BDS code 4,0	a3280030a40000	a3280030a40000	a3280030a40000
BDS code 5,0	fff8cf1f800489	a3280030a40000	ffb8cf1f80048a

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APPENDIX 3: A Brief Introduction of Mode S DAPs Data Source

1. Introduction

1.1 During the 2nd meeting of ICAO APAC Mode S DAPs WG, China presented an information paper regarding the Mode S DAPs data source, the meeting was of the view that the content of the paper will help in the understanding of the basic mechanism of avionics relevant to surveillance application and implementation of DAPs.

-Refer to Mode S DAPs WG/2 IP05 "Preliminary Study of DAPs Data Sources"

1.2 The Mode S DAPs provides useful information on aircraft that will enhance ATM operations. More attention should be paid when introducing Mode S DAPs and it's important to clearly understand what these parameters are and where these parameters come from. This text provides give some brief information about the parameters.

2. Mode S DAPs ELS and EHS

2.1 Mode S DAPs-based surveillance includes ELS (Elementary Surveillance) and EHS (Enhanced Surveillance).

2.2 Most of the ELS parameters are capability parameters of the aircraft, hence are static. They can be used for improved aircraft identification, and have less direct impact on ATC operations. The ELS parameters are shown in Table 2.1.

Table 2.1 ELS Parameters Information

	Register	DAP Set	Bits	Units	Quantity	Range
ELS		24-Bit Aircraft Address (AA)	NA	NA	NA	NA
		Transponder Capability (CA)	NA	NA	NA	NA
		Flight Status (FS)	NA	NA	NA	NA
		Altitude Reporting in 25ft	NA	ft	25	[-1000, 50175]
	BDS 1,0	Datalink Capability Report	56	NA	NA	NA
	BDS 1,7	Common GICB Capability Report	56	NA	NA	NA
	BDS 2,0	Aircraft Identification Report	56	NA	NA	NA
	BDS 3,0	ACAS Resolution Advisory Report	9-22	NA	NA	NA

2.3 EHS parameters are more related to the aircraft's intention and status, and most of them are dynamic. The implementation of EHS parameters has a larger impact on controllers. The EHS parameters are shown in Table 2.2.

Table 2.2 EHS Parameters Information

	Register	DAP Set	Bits	Units	Quantity	Range
EHS	BDS 4,0	Selected Altitude (MCP/FCU)	2-13	ft	16	[0, 65520]
		Selected Altitude (FMS)	15-26	ft	16	[0, 65520]
		Barometric Pressure Setting	28-39	mb	0.1	[0, 410]
	BDS 5,0	Roll Angle	3-11	dg	45/256	[-90, +90]

	True Track Angle	14-23	dg	90/512	[-180, +180]
	Ground Speed	25-34	kt	2	[0, 2046]
	Track Angle Rate	37-45	dg/s	8/256	[-16, +16]
	True Airspeed	47-56	kt	2	[0, 2046]
BDS 6,0	Magnetic Heading	3-12	dg	90/512	[-180, +180]
	Indicated Airspeed	14-23	kt	1	[0, 1023]
	Mach No	25-34	NA	2.048/512	[0, 4.092]
	Barometric Altitude Rate	37-45	ft/min	32	[-16384, +16352]
	Inertial Vertical Velocity	48-56	ft/min	32	[-16384, +16352]

3. Mode S DAPs Data System

3.1 The ELS and EHS parameters originate from varies sensors and cockpit settings. After being organized by the avionics systems, the information is being sent to the transponder through standard aircraft data buses, and subsequently formatted by the transponder and stored inside the relevant Binary Data Storages (BDS). The ground-based surveillance system could downlink desired DAPs by specific Mode S GICB (Ground Initiated Comm-B) protocol.

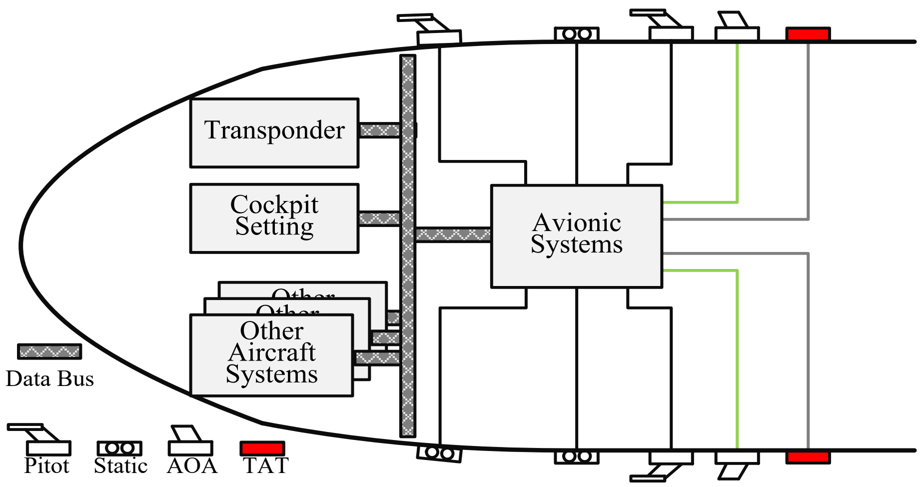


Figure 3.1 Typical DAPs Data Source Block Diagram

<u>Transponder and TCAS Computer</u>

3.2 The most common standard of the civil aircraft transponder, the Mark 4 Air Traffic Control Transponder, is based on the ARINC 718A standard. There are 3 main interface plugs defined on the rear panel, namely TP (Top Plug), MP (Middle Plug), and BP (Bottom Plug).

3.3 The airborne collision avoidance system, Traffic Computer TCAS and ADS-B Functionality, is based on the ARINC 735B standard, . There are 6 main interface plugs defined on the rear panel, namely LTP (Left Top Plug), LMP (Left Middle Plug), LBP (Left Bottom Plug), RTP (Right Top Plug), RMP (Right Middle Plug) and RBP (Right Bottom Plug).

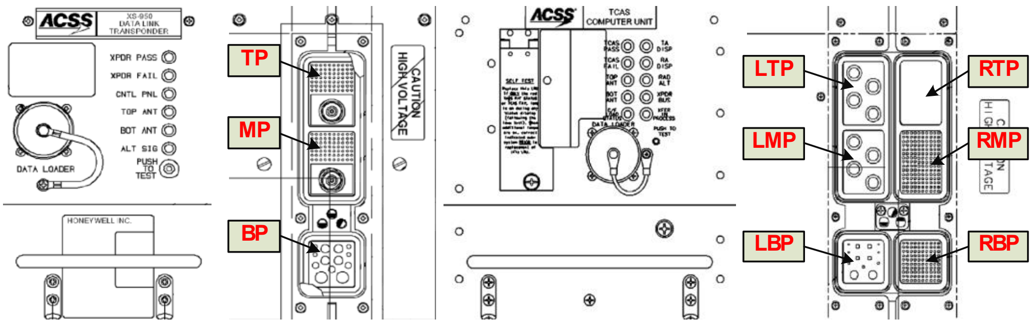


Figure 3.2 Transponder and TCAS Computer Examples from ACSS

Data Bus

3.4 The most common data bus, the Digital Information Transfer System, is based on the ARINC 429 standard. The standard defines the data transfer between most of the avionics systems. There are also other standards such as the ARINC 629 used on Boeing B777, Airbus A330 and A350, as well as the ARINC 664 (AFDX, Avionics Full Duplex Switched Ethernet) used on A380 and B787.

Avionics and DAPs Data

3.5 The Aircraft Address (AA) is a parameter programmed into the aircraft frame after the address is allocated by the State registration authority. Normally there are 2 ways to program this parameter, one is to program the pins of the MP (connected for “1”, open for “0”), and the other is to use Aircraft Personality Module (ARINC 607) to store the address, and then interface to the MP.

Note: For more detailed information about Aircraft Address, refer to ARINC 718A Attachment 2B. For APM implementation guidelines, refer to ARINC 718A Attachment 9.

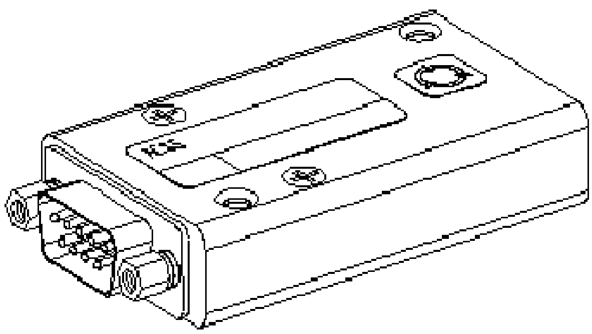


Figure 3.3 APM Example from ACSS

3.6 The Transponder Capability (CA) is a result of the combination of on-the-ground status and transponder capability level. Normally the on-the-ground status is automatically indicated by the weight sensor fitted on the aircraft, but some GA planes use manual means to indicate the status by switching the transponder knob to the GND option. The transponder receives on-the-ground status from the TP pins (5J and 5K), make validation of the status with Ground Speed, Radio Altitude or Airspeed, and then announce the status. The transponder capability level is a static value which is fixed after manufacturing.

Figure 3.4 TT31 Mode S Transponder from TRIG

3.7 The Flight Status (FS) is a result of combination of the on-the-ground status, SPI, and Alert. The on-the-ground is the same as in 3.6, the SPI is from pushing IDENT function button of the transponder by pilot, and the Alert is produced by changing Mode A code (If changed to 7500, 7600, 7700, that's permanent alert; and if changed to other codes, that's 18 seconds temporary alert).

3.8 The Common Usage GICB Capability Report is generated by the transponder itself by detecting the corresponding input data availability, and then set the corresponding bit related to that GICB register.

3.9 The main source of Aircraft Identification is from FMS, input by pilot through Flight ID (or Flight No) menu, and the related data transmitted to transponder by specific data bus (ARINC 429 Labels 233~237). If the Flight ID is empty, then the Aircraft Registration data may be provided within another data bus (ARINC 429 Labels 301-303).

3.10 According to TCAS standard (ARINC 735B Chapter 3.3.4.1), the Datalink Capability Report and the Resolution Advisories Report are sent to the Transponder from TCAS Computer by specific protocol (TGD-TCAS to Transponder data transfer protocol, and Transponder to TCAS data transfer protocol is named XGD. The data bus used is ARINC 429 Label 270). The data are sent from RMP of the TCAS Computer to TP of the Transponder, related pins refer to Figure 3.5.

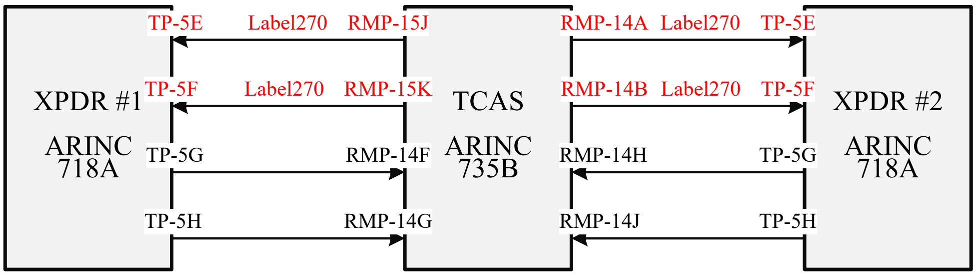


Figure 3.5 Illustrations of Datalink Capability and RA Report Transfer

3.11 There are 2 kinds of Selected Altitude, one is from MCP/FCU (Boeing's Mode Control Panel and Airbus's Flight Control Unit), and the other is from FMS (Flight Management System). The first one is set by the pilot in response to a controller's instruction during the flight, the second one is calculated by the FMS automatically to achieve the best cost-efficient.

Figure 3.6 MCP of Boeing B787 & FCU of Airbus A380

3.12 The Barometric Pressure Setting (BPS) is also located in the MCP/FCU, and set by the pilot rotating the knob to the pressure value comes from the aerodrome's ATIS (Automatic Terminal Information System).

3.13 The other parameters mainly come from the sensors onboard the aircraft, the sensors are organized in 3 groups, the air data sensors, the inertial sensors and the magnetic sensor.

3.14 The air data sensors are used to sense the medium through which the aircraft is flying, including pitot (static) probe, static port, temperature sensor, angle of attack sensor. Typical sensed parameters are total pressure (Pt), static pressure (Ps), pressure changing rate, air temperature (TAT), and angle of attack. Derived data includes Barometric Altitude (ALT), Indicated Airspeed (IAS), Vertical Speed (VS), Mach (M), Static Air Temperature (SAT), Total Air Temperature (TAT), True Airspeed (TAS) and Angle of Attack (AOA). The simplest system provides ALT and IAS.

Figure 3.7 Air Data Sensors and Integrated Sensor on Airbus A380

3.15 The inertial sensors are used to detect the motion of the aircraft in a universal reference system, including position gyroscopes, rate gyroscopes and accelerometers. By detection of the 3D dynamic of the aircraft, derived data includes Ground Speed (GS), Wind Speed, Wind Direction, True Track Angle, Roll Angle, and Track Angle Rate and so on.

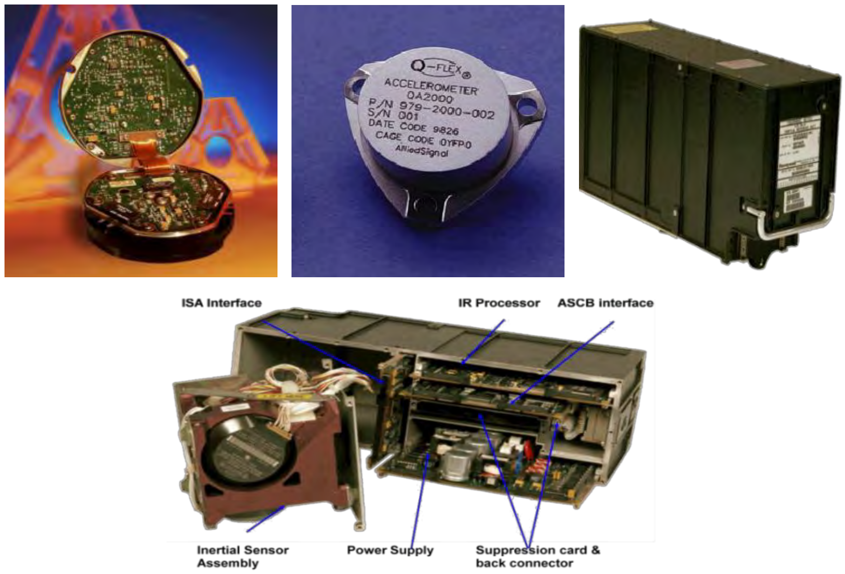


Figure 3.8 Gyro, Accelerometer and LASEREF IV IRU from Honeywell

3.16 The magnetic sensor is used to sense the direction and to find the magnetic north, and give out the main parameter of Magnetic Heading. The world magnetic model is show below:

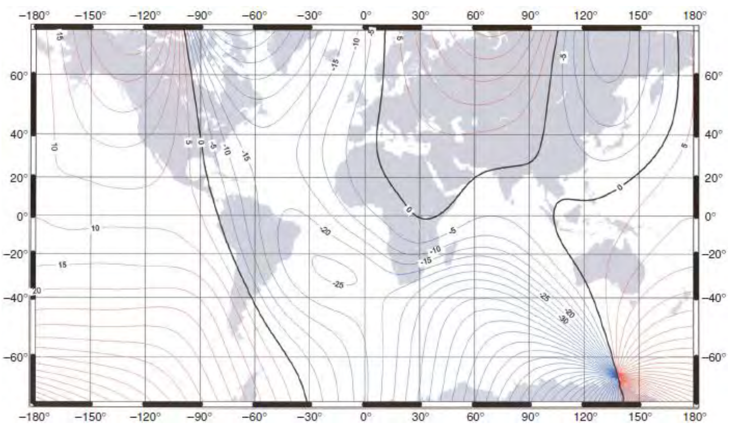


Figure 3.9 World Magnetic Model 2000

3.17 Some airplane platform uses an integrated solution to process these data, each air data sensor is connected with an Air Data Module (ADM) which converts the analog data to digital data and make the compensation of the instrumental and positional error. These data then feed to the input of Air Data Inertial Reference Systems (ADIRS) to calculate all the parameters mentioned before. And after that the parameters are sent to transponder and other avionics systems by the Data Bus.

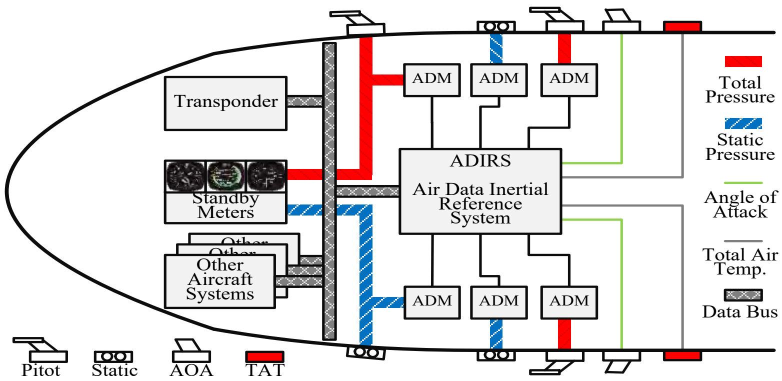


Figure 3.10 Typical ADIRS Architecture

3.18 The most commonly used data bus for parameters from ADIRS is ARINC 429 (and the newest evolution is AFDX invented by Airbus and implemented in varies new aircrafts like A380 and B787), and the standard ARINC 429 Labels used by these parameters are as follows:

Table 3.1 ADIRS Parameters Used Labels of ARINC 429

No	DAP Item	Label
1	Mach No.	205
2	Indicated Air Speed	206
3	True Air Speed	210
4	Barometric Altitude Rate	212
5	Ground Speed	312
6	True Track Angle	313
7	Magnetic Heading	320
8	Roll Angle	325
9	***Track Angle Rate***	***335****
10	Inertial Vertical Velocity	365

**Note: This label in GAMA configuration is not used for Track Angle Rate*

3.19 By using these parameters, the aircraft dynamic is illustrated as in Figure 3.11.

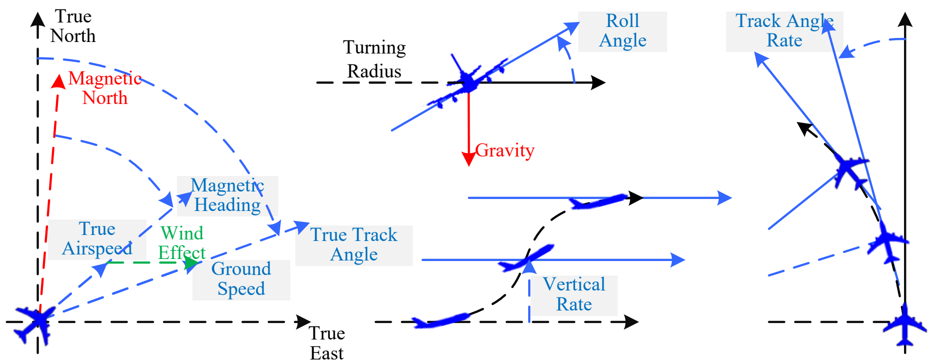


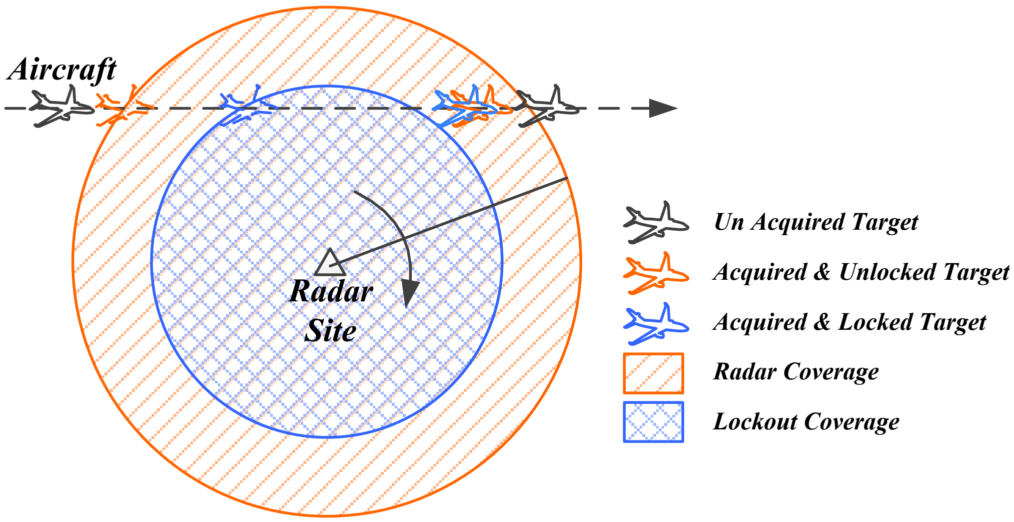
Figure 3.11 Illustration of Aircraft Dynamic

left to blank

APPENDIX 4: Mode S Parameter Set

*Radar Coverage **R***

1.1 The Mode S radar coverage is defined as the farthest target the radar will process. If the Mode S radar uses a lockout map, the difference of the two coverage ranges should be noticed.



1.2 The radar coverage will decide the minimal All-Call period, this is to say, the time of All-Call period should:

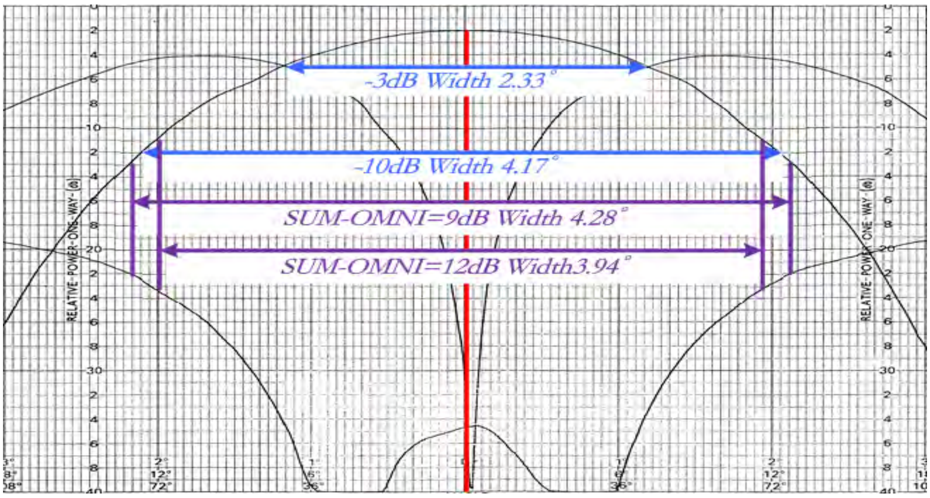
$$T \geq \frac{R * 2 * 1852}{3 * 10^8}$$

*Antenna Period **Ta***

2.1 The antenna period is the time of a successful antenna rotation, this time actually has very important influence of the total time resource of the radar. Lower antenna rotation speed will provide rich antenna period, hence time resource of the radar. The most commonly used antenna period is 4000ms (15rpm) and 6000ms (10rpm) for terminal surveillance radar.

*Antenna Beamwidth **B***

3.1 Most of the secondary surveillance radar uses the same LVA antenna, the beam is more or less the same, and the standard interrogation beam has a -3dB width of 2.45° ±0.25 °. In Mode S interrogation, the suppression requirement actually allow to use a wider beam width than -3dB width, most of the radar choose 3.8° or roughly the -10dB beam width.



*Time on Target **Tt***

4.1 The time on target is the total time amount the radar beam covers the target during one scan, it defines the time resource upper limit for one dedicated target, it is determined by both the antenna period and the beamwidth, and the relation is as follows:

$$Tt = \frac{Ta}{360} * B$$

4.2 It should be noticed that during a mix air operation (Conventional targets and Mode S targets flying in the same area in the same time), there is a need for the Necessary Transaction. That is during an antenna scan, there should be at least 4 transactions between the radar and the conventional target, in order not to miss conventional target.

*All-Call Period **Tac** and Roll-Call Period **Trc***

5.1 The All-Call period and Roll-Call period setting are different radar by radar, but there should be some principles:

1) All-Call period should long enough to allow the coverage requirement;

2) During the time on target, the Necessary Transaction should be guaranteed;

3) Time resource should allocate to Roll-Call as much as possible; and

4) Algorithm should be used to optimize the scheduling in the Roll-Call period.

*Mode Interlace Pattern **MIP***

6.1 Mode Interlace Pattern defines the radar operating mode setting. The setting is related to the specific radar environment, hence there is no standard MIP.

6.2 All the modes Mode S radar can use is listed in the following table:

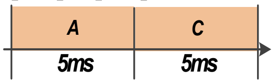
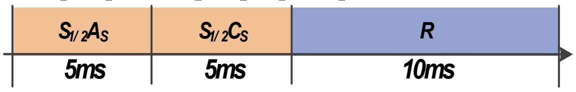
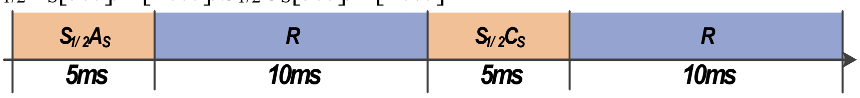
No.	Mode	Description	Pulse Used
1	A	Mode A interrogation	8μs between P1 and P3
2	C	Mode C interrogation	21μs between P1 and P3
3	A_S	Mode A Only All-Call	8μs between P1 and P3, and short P4
4	C_S	Mode C Only All-Call	21μs between P1 and P3, and short P4
5	S_L	Mode ACS All-Call	8μs, 21μs between P1 and P3, and Long P4
6	S_{PO}	Mode S Only All-Call P for PR,O for LO	2μs between P1 and P2, and P6 UF11 inside P6
7	R	Mode S Roll-Call	2μs between P1 and P2, and P6 UF0/4/5/16/20/21 inside P6

6.3 For a specific MIP, the describe phraseology defines as follows, and also one example is listed below:

Mode[Time]/ Mode[Time]/ Mode[Time]/......

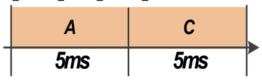
Note: The All-Call and Roll-Call periods are separated by "/", the "Mode" is one of the Modes listed above, and the "[Time]" stands for the duration of the periods.

6.4 An example is show as follows:

No.	Mode	MIP
1	Conventional	A[5.0]/C[5.0]  Mode A and Mode C repeat, both duration are 5ms
2	Mode S #1	$S_{1/2}A_S$[5.0]/$S_{1/2}C_S$[5.0]/R[10.0]  2All-Call periods and 1 Roll-Call period repeat, All-Call duration is 5ms, Roll-Call duration is 10ms In the first All-Call, the PR=1/2, and use Mode A with short P4 In the second All-Call, the PR=1/2, and use Mode C with short P4
3	Mode S #2	$S_{1/2}A_S$[5.0]/R[10.0]/$S_{1/2}C_S$[5.0]/R[10.0]  1All-Call,1Roll-Call,1All-Call,1Roll-Call repeat, All-Call duration is 5ms, Roll-Call duration is 10ms In the first All-Call, the PR=1/2, and use Mode A with short P4 In the second All-Call, the PR=1/2, and use Mode C with short P4

*<u>Interrogation Repetition Frequency **IRF**</u>*

7.1 The Mode S introduced the Roll-Call period, which makes the interrogation repetition frequency a little bit different from the Conventional Mode. There is a need to define the interrogation repetition frequency by Mode IRF_{Mode}. Normally use IRF stands for the IRF_{AC} of Conventional mode and IRF_S of the Mode S All-Call. One example is listed below:

No.	MIP	IRF
1	A[5.0]/C[5.0] 	IRF_A=100Hz IRF_C=100Hz IRF_{AC}=200Hz
2	$S_{1/2}A_s$[5.0]/R[10.0]/$S_{1/2}C_s$[5.0]/R[10.0] 	IRF_A=38.5Hz IRF_C=38.5Hz IRF_{AC}=76.9Hz IRF_S=76.9Hz IRF_R=76.9Hz

<u>DAPs Extraction Strategy</u>

8.1 The DAPs extraction strategy normally includes the BDS number, extraction priority, extraction period, and re-extraction.

1) BDS number stands for the setting of the number of BDSs which radar is going to extract. It doesn't include the ELS registers, these registers should not be extract periodically;

2) Extraction priority stands for the priority of each BDS when the radar is performing extraction, the priority should be in accordance to the user's needs;

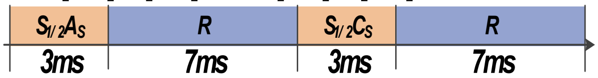
3) Extraction period stands for the period of the dedicated BDS extraction, normally described by the antenna scan number;

4) Re-extraction stands for the function of re-extraction of the dedicated BDS in the same beam dwell when the extraction is failed, but it's not recommend to re-extraction of more than 2 times.

<u>Mode S Parameter Set Example</u>

9.1 The following is an example of the Mode S Parameter Set:

No.	Parameter	Unit	Value	Note
1	R Coverage Range	NM	200	Equivalent All-Call Time $\frac{200*2*1852}{3*10^8}*10^3 \approx 2.47ms$
2	Ta Antenna Period	ms	3800	Antenna Rotation Period
3	B Work Beamwidth	°	3.8	Mode S Work Beamwidth Normally Greater Than -3dB width of 2.45°
4	Tt Time on Target	ms	40.1	The Time on Target In One Scan $\frac{3.8}{360}*3800 \approx 40.1ms$
5	Tac	ms	3.0	Equivalent Coverage Range

	All-Call Period			$\frac{3 * 10^8 * 3.0 * 10^{-3}}{1852 * 2} \approx 243\text{NM}$
6	Trc Roll-Call Period	ms	7.0	This Period Related To The Extraction Efficiency
7	MIP	——	——	$S_{1/2}A_s$[3.0]/R[7.0]/$S_{1/2}C_s$[3.0]/R[7.0] 
8	IRF_{AC}	Hz	100	Interrogation Repetition Frequency of Mode S All-Call
9	DAPs Extraction	——	——	No. of BDS: 3 (BDS 4,0 5,0 6,0) Extra. Priority: BDS 4,0 6,0 5,0 Extra. Period: 1 Scan Re-Extraction: Yes

INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

REGIONAL SUPPLEMENT

TO

THE ASTERIX INTERFACE CONTROL DOCUMENT (ICD) FOR THE ASIA/PAC REGION

THIRD EDITION

October 2021

Issued by the ICAO Asia/Pacific Regional Office, Bangkok

TABLE OF CONTENTS

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Regional Supplement to the
*All Purpose **ST**ructured **E**urocontrol Su**R**veillance*
***I**nformation **EX**change (ASTERIX) ICD*
for the ASIA/PAC Region

System Area Code (SAC)

ADDRESSING SCHEME OF ~~RADAR~~ SURVEILLANCE DATA EXCHANGE

1. General

In order to avoid ambiguity, every ~~radar~~ system shall have a unique identification in an area where ASTERIX is used for the exchange of~~(i.e. radar sensor, radar data processing system, server) shall have a unique identification within the Asia and Pacific regions to represent either a radar source or a sink, participating in the radar data exchange~~.

2. Syntax

The ASTERIX System Identifier format shall be composed of two subfields as illustrated~~The format of System Identifier field of radar data exchange shall be composed of two subfields as illustrated below~~:

SAC	SIC

	Field Name	Element Type	Field Size
SAC	System Area Code	Binary	One octet
SIC	System Identification Code	Binary	One octet

2.1 System Area Code (SAC)

2.1.1 The SAC field shall consist of an eight-bit number assigned to a country or a territory.

2.1.2 The SAC field format shall be as illustrated below:

MSB

b8	b7	b6	b5	b4	b3	b2	b1

Where: b represents a binary digit and the MSB stands for Most Significant Bit

2.1.3 System Identification Code (SIC)

2.1.3.1 The SIC shall consist of an eight-bit number assigned to every system (surveillance station, processing system, server, etc.) located in the geographical area or country defined by the SAC.~~The SIC shall consist of an eight-bit number assigned to each radar system (radar sensor, processing system, server, etc.) located in the country or territory as defined by the SAC~~.

2.1.3.2 The SIC field format shall be as illustrated below:

MSB

b8	b7	b6	b5	b4	b3	b2	b1

Where: b represents a binary digit and MSB stands for the Most Significant Bit

2.1.4 The individual SICs are assigned by the National Administration concerned within the area identified by the SAC and are published in the this Document. SIC is managed by State and there is little value for ICAO APAC to manage the SIC. Considering the workload to manage the SIC and the negligible benefits, ICAO APAC will not manage SIC.

2.1.5 Within a country or territory identified by a SAC up to 256 individual codes (SICs) can be assigned.

2.1.6 The SICs shall be indicated by decimal and presented by binary in their relevant tables.

2.1.7 **Recommendation** *The assignment of SICs could be divided into groups by different functions and facilities categories.*

3. Assignment of the Systems Identifiers

3.1 System Area Codes

3.1.1 One SAC is assigned to each country or territory.

3.1.2 **Recommendation** *When needed, more than one SAC could be assigned to a single country or territory, for example, to differentiate between civil and military applications.*

3.1.3 The SACs allotment is provided in the Table 1 - System Area Codes (SAC)

3.1.4 Amendments to the System Area Codes (SAC) shall be coordinated by ICAO ASIA/PAC Regional office.

System Area Code (SAC) Allotment Scheme
(by country alphabet order and even hexadecimal numbers)

Table 1 - System Area Codes

SAC (Hexad)	Country/ Geographical Area	Binary Representation	SAC (Hexad)	Country/ Geographical Area	Binary Representation
A2	Afghanistan	1010 0010	44	Maldives	0100 0100
02	American Samoa	0000 0010	46	Marshall Islands	0100 0110
04	Australia	0000 0100	48	Micronesia	0100 1000
A4	Australia	1010 0100	50	Mongolia	0101 0000
06	Bangladesh	0000 0110	52	Myanmar	0101 0010
08	Bhutan	0000 1000	54	Nauru	0101 0100
10	Brunei Darussalam	0001 0000	56	Nepal	0101 0110
12	Cambodia	0001 0010	58	New Caledonia	0101 1000
16	China	0001 0110	60	New Zealand	0110 0000
1A	China	0001 1010	62	Niue Island	0110 0010
1C	China	0001 1100	64	Pakistan	0110 0100
A6	China	1010 0110	66	Palau	0110 0110
AA	China	1010 1010	68	Papua New Guinea	0110 1000
18	Hong Kong, China	0001 1000	72	Philippines	0111 0010
40	Macao, China	0100 0000	74	Republic of Korea	0111 0100
20	Taibei, China	0010 0000	76	Samoa	0111 0110
22	Cook Islands	0010 0010	78	Singapore	0111 1000
24	DPR. of Korea	0010 0100	80	Solomon Islands	1000 0000
26	Fiji	0010 0110	82	Sri Lanka	1000 0010
28	French Polynesia	0010 1000	84	Thailand	1000 0100
30	India	0011 0000	86	Tonga	1000 0110
32	Indonesia	0011 0010	88	Tuvalu	1000 1000
34	Japan	0011 0100	90	United States	1001 0000
36	Kiribati	0011 0110	92	Vanuatu	1001 0010
38	Lao PDR.	0011 1000	94	Vietnam	1001 0100
42	Malaysia	0100 0010	96	Wallis Islands	1001 0110

* 14, 70 is intentionally left blank

Revised TERMS OF REFERENCE

STUDY GROUP UNDER SURICG ON SHARING OF SURVEILLANCE DATA IN SWIM

Working Arrangement of the Study Group

Membership: The Study Group under SURICG on Sharing of Surveillance Data in SWIM ("Study Group", "SURSG**"** as acronym) shall be composed of subject matter experts from Member States involved in the provision of surveillance services and SWIM development as well representatives from Member States with an interest to contribute to the works of the SURSG. The SURSG may invite representatives of International Organizations recognized by the ICAO Council, Industry Partners or interested parties representing important civil aviation interests to participate in its work in consultative capacity.

Participants of SURSG/1 *(in alphabetical order)***:**

Australia, China, Hong Kong - China, India, Indonesia, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Singapore, Thailand, United States, Viet Nam, CANSO, IATA, ICCAIA.

The SURSG shall have one elected Chair.

The SURSG shall have Task Leads and Sub-Task Leads for tasks detailed in the "Deliverables to meet the Objectives", which currently features 4 main Tasks together with their sub-tasks. Members may volunteer to subscribe to the tasks and sub-tasks. Task Leads and Sub-Task Leads are to be selected through coordination and agreement among the respective task or sub-task subscribers.

Meetings: While the SURSG is established in ad hoc nature, it shall convene face-to-face/web meeting to achieve its TOR. Outcome of its meetings shall be reported to and sought endorsement from the SURICG. Progress of the SURSG shall also be shared with SWIM TF and CRV OG via their nominated representatives joining the SURSG.

Task Leads and Sub-Task Leads shall convene meetings as necessary and in formats as appropriate to discuss and work on their tasks to achieve the scheduled deliverables making reference to Deliverables Template, a temple of which is provided on the last page of this ToR.

Task Leads and Sub-Task Leads shall attend the SURSG meetings and in between SURSG meetings, ad-hoc or regular meetings to harmonize their work or resolve issues.

Schedule and delivery: Subject to the extent of prioritized applications considered by the SURSG, the schedule for delivery of the SURSG shall be decided by the SURSG, which shall update the SURICG accordingly.

The Objectives of Study Group are to:

1) Study, provide expert views and recommendations:
    a) to achieve harmonized sharing of surveillance data in SWIM in the Asia and Pacific Regions (APAC) according to Surveillance Strategy adopted by APANPIRG and in support of ICAO's GANP and ASBU initiatives; and

   b) on the possible models of sharing surveillance data in SWIM in the SWIM environment, in consideration of the SWIM technical infrastructure, SWIM information service, CRV infrastructure and any applicable governance, and technical requirements.

2) Review, identify and provide expert views and recommendations to address major issues, raised to the SURSG by ICAO APAC, in the technical, operational or regulatory aspects of surveillance data sharing to facilitate the implementation of surveillance from "departure to destination" in APAC.

Deliverables to meet the Objectives:

1) To submit not fewer than 1 Progress Report per year to SURICG and SWIM TF, with the latest report submitted at least 2 months prior to convening of the SURICG meeting on the Study Group deliverables (listed in 2 to 4 below);

2) To study, identify and make recommendations on the **possible and practical** models for surveillance data sharing in SWIM in APAC with considerations of:

a) Concept of use/operation;
b) System design considerations of individual participant that shares surveillance data such as system robustness, data security and integrity, data latency, fallback arrangements and system recovery;
c) General requirements from perspective of collaborative sharing of surveillance data such as centralized/decentralized surveillance data processing, data repository, service registry, service resilience and service recovery;
d) Required commitments of data sharing participants such as commitment of resources and costs;
e) Implementation roadmap and time frames with consideration of
    (i) An incremental approach/a comprehensive approach at the outset;
    (ii) Type(s) of surveillance data to be shared; and
    (iii) Information exchange model for surveillance data in SWIM;
f) SWIM technical infrastructure, SWIM information service, CRV infrastructure;
g) Other currently available or emerging technologies; and
h) ICAO Global Air Navigation Plan (GANP) and Aviation System Block Upgrades (ASBU) as well as APAC Seamless ANS Plan.

3) To prepare, based on its works in 2) above, a report on the possible implementation of surveillance data sharing in SWIM in APAC inclusive of the following:

a) Recommendations for:
    (i) An incremental approach/a comprehensive approach at the outset in surveillance data sharing;
    (ii) Type(s) of surveillance data to be shared; and
    (iii) Exchange model of surveillance data in SWIM.
b) Pros and cons and cost effectiveness for the possible models that have been considered and a recommendation on the best approach or parallel approaches;
c) Concept(s) of Operations of the recommended approach(es);
d) Required commitments of participating Member States who share their surveillance data;
e) Required commitments of Member States who access the shared surveillance data; and
f) Draft multi-lateral agreement on surveillance data sharing and data consumption.

4) To develop guidance materials to assist Members States participating in the sharing of surveillance data and Member States accessing the shared surveillance data.

Template of Deliverables

		Efforts thus far
1	Study, provide expert views and recommendations: a) to achieve harmonized sharing of surveillance data in SWIM in the Asia and Pacific Regions (APAC) according to Surveillance Strategy adopted by APANPIRG and in support of ICAO's GANP and ASBU initiatives; and b) on the possible models of sharing surveillance data in SWIM environment, in consideration of the SWIM technical infrastructure, SWIM information service, CRV infrastructure, and any applicable governance, and technical requirement.	
2	Review, identify and provide expert views and recommendations to address major issues, raised to the SURSG by ICAO APAC, in the technical, operational or regulatory aspects of surveillance data sharing to facilitate the Mode S DAPs implementation in APAC.	
Deliverables to meet the Objectives:		**Efforts thus far**
1	To submit not fewer than 1 Progress Report per year to SURICG and SWIM TF , with the latest report submitted at least 2 months prior to convening of the SURICG meeting on the SURSG deliverables (listed in 2 to 4 below)	
2	To study, identify and make recommendations on the possible and practical models for surveillance data in SWIM in APAC with considerations of : a) Concept of use/operation; b) System design considerations of individual participant that shares surveillance data such as system robustness, data security and integrity, fallback arrangements and system recovery; c) General requirements from perspective of collaborative sharing of surveillance data such as centralized/decentralized surveillance data processing, data repository, service registry, service resilience and service recovery; d) Required commitments of data sharing participants such as commitment of resources and costs; e) Implementation roadmap and time frames with consideration of: (i) An incremental approach/a comprehensive approach at the outset; (ii) Type(s) of surveillance data to be shared; and (iii) Information exchange model for surveillance data in SWIM. f) SWIM technical infrastructure, SWIM information service, and CRV infrastructure; g) Other currently available or emerging technologies; and	

	h) ICAO Global Air Navigation Plan (GANP) and Aviation System Block Upgrades (ASBU).	
3	To prepare, based on its works in 2) above, a report on the possible implementation of surveillance data sharing in SWIM in APAC inclusive of the following: a) Recommendations for: (i) An incremental approach/a comprehensive approach at the outset in surveillance data sharing; (ii) Type(s) of surveillance data to be shared; and (iii) Information Exchange model for surveillance data in SWIM. b) Pros and cons and cost effectiveness for the possible models that have been considered and a recommendation on the best approach or parallel approaches; c) Concept(s) of Operations of the recommended approach(es); d) Required commitments of participating Member States who share their surveillance data; e) Required commitments of Member States who access the shared surveillance data; and f) Draft multi-lateral agreement on surveillance data sharing and data consumption.	
4	To develop guidance materials to assist Members States participating in the sharing of surveillance data and Member States accessing the shared surveillance data.	

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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 50 ADS-B ground stations and 28 WAM stations are operational (Total 78) ATC readiness since 2004 ADS-B data sharing with Indonesia operational since 2/2011. ASMGCS using multilateration and ADS-B is operational in Brisbane, Sydney, Melbourne and Perth November 2016 – ADS-B converted to “radar like” Cat 48 for use in Melbourne Terminal Area and Perth Terminal Area in early 2017. CMATS replacing the current ATM system is expected to be fully operational in 2026 period.	2009/effective date of mandating in upper airspace 12/12/2013. An ADS-B mandate for all IFR aircraft applies from 2/2017. Some limited exemptions for foreign registered aircraft and some private operations.	All airspace for IFR aircraft from 2/2017	2.5NM, 3NM and 5 NM surveillance separations. 3/2016 - Manual of ATC updated to include 3 nautical mile separation using ADS-B in terminal control unit. 3/2017 – 2.5NM separation authorized using ADS-B when also used with radar. 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. CASA has approved the use of reduced specification ADS-B avionics to support ADS-B IN and ATC situational awareness for VFR aircraft

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 install 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 ATM system at Dhaka. Bangladesh has also a plan to install MLAT stations to provide surface movement control at HSIA, Dhaka as well as TMA coverage as a backup and complimentary RADAR coverage to the Dhaka MSSR.				Bangladesh is willing to share ADS-B data with neighbouring States to enhance the safety and surveillance capability in the sub-region.
BHUTAN	ADS-B ground infrastructure feasibility study will be completed in the middle of 2020.	Equipage mandate will be issued once after the completion of feasibility study.			
BRUNEI DARUSSALAM	5 ADS-B ground stations with WAM functionality installed in 2015 and full operation in October 2016. ADS-B/WAM data are fused with radar data in the TopSky ATC Automation system (Thales) to enhance full radar surveillance coverage for Brunei Darussalam. Memorandum of Understanding (MOU) on ADS-B data sharing with Singapore and Brunei				

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
	Darussalam is expected to sign in April 2019.				
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 are used for flight training of CAFUC. The upgrade to 1090ES ADS-B stations project has already started in 2017, and the project is planned to finish by 2022. 308 ADS-B stations nationwide have already finished the final acceptance activities. 4 ADS-B stations operational in Sanya FIR since 2008. Chengdu-Jiuzhai and Chendu - Lhasa route with 9 ADS-B stations.	The operation of national ADS-B Service is implementing in step -by-step way. Phase I: from October 10, 2019 ➢ ADS-B control services will be provided in APP where radar control services are not available; ➢ ADS-B control services will be implemented in control area above 8400m (inclusive) where Radar control services are not available; ➢ Radar control services will be provided, using integrated surveillance data of ADS-B and radar, in control areas above 8400m (inclusive) where radar control services are available.	The ADS-B mandate published in October 2020, in a separated AIC Nr.09/19 named “Implementation of ADS-B Control Services”		

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
	9 ADS-B stations deployed on the routes H15 and Z1 by the end of 2015. 19 ADS-B stations at the small airport.	Phase II: from December 31, 2020 ➢ ADS-B control services will be provided in APP and ACC where radar control services are not available; ➢ Radar control services will be provided, using integrated surveillance data of ADS-B and radar, in APP and ACC where radar control services are available; and ➢ ADS-B equipment will be used at the tower of transport airports to display flight movements.			
HONG KONG CHINA	A larger-scale A-SMGCS covering the whole Hong Kong International Airport put into operational use in April 2009. 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.	AIP supplement issued on 29 Aug 2014 with 8 Dec 2016 as effective date.	HKFIR at or above FL290	5NM surveillance separation	Fully implemented ADS-B in HKFIR by phased approach to ensure safe and smooth integration of ADS-B into the Air Traffic Management System to provide aircraft separation service since November 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
	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 has been effective since December 2016. ADS-B ground station infrastructure completed in 2013. ADS-B signal provided by Mainland China to cover southern part of Hong Kong FIR commenced in 2010 and has been put into operational use after commissioning of the new ATMS since November 2016.				
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.	ADS-B mandate commencing from 31st December 2013	Mandate for domestic registered aircraft.		

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
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, Hyderabad, Jaipur, Amritsar, Lucknow, Ahmedabad and Guwahati Airports. ASMGCS (SMR+MLAT) proposed at Cochin and Bhubaneswar (VOCI&VEBS) Expected to be completed by March 2022. ADS-B Ground Stations are installed at 36 locations to cover continental and Oceanic airspace. Out of these 36 ADS-B ground receivers, 25 receivers have been operationalized and remaining 11 ADS-B ground	AIP supplement issued on 25th October, 2018 with effective date of implementation from 01st January 2019 which was subsequently revised through NOTAM G1995/18 to be effective from 01st January 2020.	On all ATS Routes within continental airspace at and above F290.	a) 5 NM within 60 NM of ADS-B ground station i.e. in the terminal airspace served by the ADS-B receiver. b) 10 NM beyond 60NM of ground station i.e. in the en route airspace.	Standalone ADS-B based APP Surveillance service provided at VOCL, VOCB, VEPT, VEAT and VIJP. MSSR/ADS-B integrated mode APP Surveillance service provided at VILK, VOML, VEBN and VANP.

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
	receivers will also be operationalized soon. ATM automation systems at 22 ATC Centres are capable of processing ADS-B data.				
INDONESIA	All 30 ADS-B ground station have been met with DO260B in November 2019; The 18 new ADS-B ground stations, with DO260B capability, will be established to cover the traffic in terminal and area. The 7 ADS-B ground station has been installed in Papua. The rescheduling of completion for 11 ground stations in 4Q2021. The ADS-B ground stations has been integrated to 9 ATC systems and 3 others will follow after being upgraded.		Starting on 23rd April 2020, Indonesia has implemented mandatory ADS-B equipment for all transport aircraft category flying at all level (SFC up to FL600) in 2 ACCs, 9 TMAs and 10 Airports.	Using 5 NM separation standard.	ADS-B data sharing had been conducted by Indonesia with Australia and Singapore. LOA of collaboration in ADS-B data sharing has been achieved with India. LOA of collaboration in ADS-B data sharing are under reviewing by Malaysia, Philippines and PNG.

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
JAPAN	Multilateration Systems for surface monitoring have been implemented at eight airports PRM (WAM) has been implemented at Narita Airport and Haneda Airport. En-route WAM system have manufactured for four areas and will be put into operation in FY2021 Plan to evaluate accuracy of ADS-B information under RAD condition.				
KIRIBATI					
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				

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 2017 to enhance the full ADS-B coverage of Lao FIR.				
MALAYSIA	Ground Infrastructure: Kuala Lumpur FIR: 1. Installation of two (2) ADS-B GS in Langkawi and Genting has been completed in October 2017. 2. Upgrading of Kuala Terengganu ADS-B for ADS-B Version 2 capability is to be completed at the end of Dec 2021. 3. Operation of all three ADS-B in new Kuala Lumpur ATC System is to be completed in Dec 2021. Kota Kinabalu FIR: Four (4) new ADS-B will be installed in Kuching, Bintulu, Kota Kinabalu and Sandakan, to be completed in Dec 2021. Implementation Plan: Phase 1: ADS-B services on specific ATS routes and Flight Levels within Kuala Lumpur FIR, target date Mar 2021. Phase 2: ADS-B as secondary means of surveillance within the Kuala Lumpur FIR for en-route airspace. Target date: Mar 2022.	AIC Issued on September 2017. AIP Supp on 16 Jan 2020.	Phase 1: On ATS routes N571, P628, L510, P627, L645 and P574 at FL 290 to FL 410 within Kuala Lumpur FIR Phase 2: En-route airspace	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
	Phase 3: ADS-B used as the primary means of surveillance for en-route airspace. (TBA)				
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.
MARSHALL ISLANDS					
MICRONESIA (FEDERATED STATES OF)					

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	**a) The ADS-B Implementation Update** - The five ADS-B ground stations have been installed in Myanmar. Among them, SITTWE and CoCo Island ground stations are installed in 2014, and are DO260 compliant. The other 3 stations, YANGON, MANDALAY and MYEIK airport ground stations are DO260B compliant and installations were finished in 2016. - All ADS-B data are fused with MSSR data in the TopSky ATC Automation system (Thales) in 2016 and using as MSSR backup in Yangon ACC. **b) The ADS-B data sharing update between neighbouring States** - Myanmar and India signed the MOU agreement for ADS-B data	Doing ADS-B data analysis and statistic for ADS-B equipped Aircraft in Yangon FIR.			Supplement radar and fill the gaps to improve safety and efficiency ADS-C/CPDLC integrated in Yangon ACC since 2010.

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
	sharing on 6th May 2015. ADS-B data sharing test between Agartala (India) - Sittwe (Myanmar), and Port Blair (India) - CoCo Island (Myanmar) have been accomplished between technical teams since June 2018. At present, the shared ADS-B data from Myanmar side is now using as backup automation system at Kolkata for test purpose. But, Myanmar side is needed to discuss with ATM manufacturer for operational use of the India's Data at Yangon ACC. - Myanmar have planned to install new ADS-B Station in the 2nd quarter of 2019 at LASHIO Airport located in north-eastern part of Myanmar closed to the China-Myanmar border near the LINSO transfer point on A599 ATS route. After the installation finished, the ADS-B data sharing process can be proceeded between Myanmar and China.				

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
NAURU					
NEPAL	Four ADS-B ground stations have been installed in 2019 at Kathmandu (Phulchowki), Bhairahawa, Nepalgunj and Dhangadi.				Safety assessment will be done soon.
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 from WAM system centred in and around Queenstown. Provides surveillance coverage for TOWER and Approach Surveillance using 5NM separation for NZQN and ENROUTE coverage of the southern half of the South Island of New Zealand MLAT and ADSB data from the NZAA MLAT system to support surface movements control at NZAA	Current: ADSB mandate FL245 and above in the NZZC FIR from DEC 31, 2018, active **Proposed:** ADSB mandate for all controlled airspace from DEC 31, 2022, promulgated by NZCAA (Delayed from 2021 by 1 year due to COVID) **Current:** Since July 2018, all new aircraft registered in New Zealand, or any currently registered aircraft upgrading transponder(s) are required to install DO260B transponder(s) which meet the NZCAA rule set. The	Current: All controlled airspace within the NZZC FIR FL245 and above. **Proposed:** All controlled airspace within the NZZC FIR	5NM surveillance separation in enroute controlled airspace, and 3NM surveillance separation in Terminal approach controlled (Class C) airspace.	Currently situational awareness surveillance targets are displayed for ADS-B targets from which the data supplied does not meet the requirements for 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
	ADSB data at 6 domestic aerodromes to provide ADSB APT surface movements control 34 ADSB-B Ground stations for Enroute, Terminal and ADSB APT services	rule specifies the minimum Technical Standing Orders (TSO) or transponder GNSS receiver models for position input into 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 2016. These stations will be DO260B compliant and operational by end of 2017.				
PAPUA NEW GUINEA	Initially 7 ADS-B sites to be deployed across PNG to provide seamless coverage above FL285. Three (3) sites installed as of December 2017. Two (2) of these are operational.First site to be installed May/June 2017, with remainder to be completed in 2018. Additional 7 sites to be rolled-out in the 2018/19 timeframe. Site location will be dependent on infrastructure, security and an analysis of Phase 1 site performance.	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 above F245 – but will depend on performance of Phase 1 ADS-B deployment.	None	**Air Traffic Control** <u>Approach/ Arrivals</u> 2018 – 5NM 2019 – 3NM (approach) <u>Upper Airspace (>FL245)</u> 2017/18 – Situational awareness. 2018/19 – 5NM	

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
	PNGASL (ANSP) will commence a transition to new ATM automation system in May 2018. The system will support fusion of ADS-B and RADAR data. 5 mile separation to be provided using ADS-B and fused ADS-B/Radar from May 2018. From 2018 onwards, PNGASL will be looking to share ADS-B data with Indonesia and Australia.	Country-wide mandate not envisaged before 2021/22.		Note: Implementation dictated by training requirements and new ATM system transition priorities. **Flight Service** Directed Traffic (FIS) 2019 – Situational awareness	
PHILIPPINES	One ADS-B GS installed at the Manila ATM Center for situational awareness. One ADS-B Ground Station installed at Bataraza, Palawan for data sharing with Singapore. Additional ground stations are planned to be installed in Laoag Airport, Tagaytay, Jomalig Island, Puerto Princesa Airport, Mt. Majic Mactan, and General Santos "Tambler" Airport.				

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
REPUBLIC OF KOREA	Installed 10 ADS-B receivers and in operation since May 2020. 3 more receivers will be installed by 2024.	To be confirmed.	To be confirmed.	To be confirmed.	
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. ADS-B OUT equipment requirement for all aircraft operating on selected ATS routes within the WSSS FIR from 27 January 2022. ADS-B OUT equipment requirement for all aircraft operating within the WSSS FIR from 26 January 2023. AIP updated in May 2018 to reflect the ADS-B equipment certified as meeting: a. EASA - (AMC 20-24), or b. EASA CS-ACNS (Subpart D - Surveillance - SUR), or c. FAA - Advisory Circular No: 20-165A (or later versions), or d. The equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of CASA.	At and above FL290, affecting the following ATS routes L642, L644, M753, M771, N891 & N892 At and above FL290, affecting the following ATS routes L517, L625, L649, M758, M767, M768, M772 & N884.	40nm implemented on ATS routes L644 and N891. 20nm implemented on ATS routes L642, M771, M753 and N892.	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
SRI LANKA	Total of 5 ADS-B Ground Receiving Stations and 01 Central Processing Station have been installed in March 2017. ADS-B Data is fused with Multi-sensor Data, including MSSR and ADS-C in the ATM system at Colombo ACC Ratmalana was launched for operational used on 15 Nov. 2017. New ATM system planned for operational at APP Centre in 2018 will also be capable of fusing Multi-sensor Data, including MSSR and ADS-B	Revised Date of Equipage mandate would be 31st Dec 2020. Ref: AIC A02/16 (Initially AIC A02/14 was issued in November 2014)	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.	On completion of a safety assessment, use of ADS-B alone for ATC separation purposes.
THAILAND	Five ADS-B ground stations (DO-260B and lower compliant) have been primarily installed for research and development purpose and are being undergone the approval process to be used for air traffic services with a target date by the end of 2021.	The airspace re-structure and aircraft equipage mandate are planned to be studied in 2021 and are expected to be started implementation in 2022.	TBD	TBD	

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
	The new ATM automation system was successfully implemented in Q1 2020. It can The ATS surveillance data sharing with the adjacent FIRs was approved in principle in October 2018.				
TONGA	Trial planned for 2017				
UNITED STATES	The US identified required ADS-B Service Volumes in 2007. Using data from over 600 terrestrial radio sites, the US domestic ADS-B system became operational in 2014. As of 1 January 2020, ADS-B aircraft equipage is mandated in most controlled airspace within the US. Over 160,000 US registered aircraft are now equipped. ADS-B is available to U.S. air traffic control facilities for ATC separation; all En Route Centers and major Terminal facilities are using ADS-B for ATC separation.	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 criteria: - 3nm - 2.5nm - independent parallel approach operations down to 3600 ft centreline separation - dependent	The U.S. has implemented integrated WAM/ADS-B in the following terminal areas: Charlotte LAX Implementation of integrated WAM/ADS-B is being considered for additional U.S. terminal areas.

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
				parallel approach operations down to 2500 ft centreline separation (currently 1.0 nm diagonal distance).	
VANUATU					
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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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 ADS-B applications in the Asia and Pacific Regions including implementation target dates taking into account:*

- *available equipment standards;*
- *readiness of airspace users and ATS providers;*
- *identifying sub-regional areas (FIRs) where there is a positive cost/benefit for implementation of ADS-B and associated VHF voice communications;~~and~~*
- *developing a standardised and systematic task-list approach to ADS-B implementation; and*
- *major traffic flows.*

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

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

11) *Facilitate implementation~~sharing~~ of surveillance ~~information~~data sharing (including DCPC) and sharing surveillance information and expertise between States through organizing educational seminars and providing guidance materials to educate States and airspace users*

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

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

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

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

Membership:

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

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

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INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ADS-B IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT

Edition ~~13~~14.0 - ~~September~~ August ~~2020~~2021

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1. INTRODUCTION

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

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

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

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

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

1.1 ARRANGEMENT OF THE AIGD

The AIGD consists of the following Parts:

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

1.2 DOCUMENT HISTORY AND MANAGEMENT

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

1.3 COPIES

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

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

1.4 CHANGES TO THE AIGD

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (see Section 1.6 below) should be completed and submitted to the ICAO Asia and Pacific Regional Office. The Regional Office will collate RFCs for consideration by the Surveillance Implementation Coordination Group.

When an amendment has been agreed by a meeting of the Surveillance Implementation Coordination Group then a new version of the AIGD will be prepared, with the changes marked by an "|" in the margin, and an endnote indicating the relevant RFC, so a reader can see the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted; e.g.:

Final approval for publication of an amendment to the AIGD will be the responsibility of APANPIRG.

1.5 EDITING CONVENTIONS

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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 2016	Proposed by ADS-B SITF/15 and adopted by APANPIRG/27	(i) Included a list of additional functional requirements for ADS-B integration (ii) Addition of a checklist of common items or parameters for monitoring of ADS-B System (iii) Amendment to emphasize the issue on potential incorrect processing of DO-260B downlinks by ADS-B ground stations during upgrade (iv) Updated the list of known ADS-B avionics problems (v) Included a general recommendation of technical solution on acquisition of Mode 3/A code information via Mode S downlink for DO-260 aircraft in ADS-B implementation with Mode A/C SSR environment
10.0	June 2017	Proposed by SURICG/2	(i) Updated "B787 position error with good NUC" in the list of known ADS-B avionics problems. (ii) Included new problem type "Incorrect Ground Bit Setting in ADS-B Avionics Downlink Data" and "A350 ADS-B on-ground performance" in the list of known ADS-B avionics problems. (iii) Amendment to the template for ADS-B Mandate / Regulations for Aircraft Avionics. (iv) Included a general recommendation to use ADS-B in overcoming the limitations of Mode A/C radar technology. (v) Included a general recommendation on carrying out ICAO Aircraft Address Monitoring

			(vi) Aligned to replace NACp for NAC throughout the document (vii) Aligned to use ICAO Aircraft Address throughout the document
11.0	April 2018	Proposed by SURICG/3	(i) Editorial Updates – including /replacing ADS-B SITF with SURICG (Sections 1, 1.4, 2.1, 7.5.1, 7.5.5, 7.5.6, 7.6, 7.8.2) (ii) Correction of HPL Definition (Section 2.2) (iii) Update of reference documents as in Attachment 2 of WP/02 (iv) Include reference to APRD (Section 7.5.1) (v) Update of sample regulations (Section 9.2) (vi) Update in Position Reporting Performance (Section 9.3.2) (vii) Update in GNSS Integrity Prediction Service (Section 9.3.3) (viii) Update name of RASMAG in Sharing of ADS-B Data (Section 9.3.4) (ix) Clarification of reporting rate requirements (Section 9.4.1) (x) Use of Ident during ADS-B emergencies.(Section 9.12) (xi) Appendix 1 missing from Version 10 – reinstate. (xii) Appendix 2 – update for available APRD. (xiii) Update to B787 service bulletin status. (Attachment A in Appendix 2) (xiv) replace "Date UTC" to "Start Time/Date UTC", replace "Time UTC" to "End Time/Date UTC" and related contents in the Report Form (Section 7.8.1) (xv) replace description of "Date UTC" as "UTC Time/Date when the event occurred", replace description of "Time UTC" as "UTC Time/Date when the event ended" as sometimes the problem will lasts across mid-night. (Section 7.8.2)

			(xvi) In Remote Control & Monitoring (RCMS) part, suggest to replace "ASTERIX Output Load" to "ASTERIX Output Load and Link Status" (Appendix 5) (xvii) Update on DO260A EMG issue (Section 9.12) (xviii) Update the link to the Guidance Material on generation, processing and sharing of ASTERIX (Section 4) (xix) Reference to Space based ADS-B and ATC automation as in WP12 is added under 5.1.4.4.6 (xx) Updated Section 4Managing the Problem in Appendix 2 to incorporate the General mechanism and procedure for blacklisting aircraft (xxi) Updated the Attachment A to Appendix 2 – List of known ADS-B avionics problems (xxii) Added Appendix 6 – Baseline ADS-B Service Performance Parameters (xxiii) Added Appendix 7 – Guidance Material on Generation, Processing and Sharing of ASTERIX Category 21 ADS-B Messages
12.0	April 2019	Proposed by SURICG/4	(i) Added procedures on handling GPS time and week counters rollover (Section 9.13) (ii) Added two new problem types to Attachment A of Appendix 2 "List of known ADS-B avionics problems", including: o Rockwell TSS-4100 Geometric Altitude Reporting as Pressure Altitude o Improper NACv reporting (iii) Updated the status of known ADS-B avionics problems in Attachment A of Appendix 2 "List of known ADS-B avionics problems", including:

			o B787 position error with good NIC o Rockwell TSS-4100 track extrapolation issue o Embraer 170 track jumping issue o Airbus Single Aisle production wiring issue o Boeing 777-300ER production wiring issue
13.0	September 2020	Proposed by SURICG/5	(i) Updated the status of known ADS-B avionics problems in Attachment A of Appendix 2 “List of known ADS-B avionics problems”, including B787 NACv = 0 Issue (ii) Updated Section 5.1.4.5.1 on ICAO Aircraft Address Monitoring (iii) Added the following new sections: o Use of ADS-B for Airport Surface Movement (Section 9.3.6) o 1090 Mhz Spectrum and 24-bit Aircraft Address Issue with Unmanned Aircraft Systems (UAS) (Section 9.3.7) o Measures for Enhancing the Security of ADS-B (Section 10.3) o Time Difference of Arrival (TDOA) Based Position Verification Method (Section 10.3.1)
14.0[MC1]	August 2021	Proposed by SURICG/6	(i) Added the following new issue to the “List of known ADS-B avionics problems” in Attachment A of Appendix 2 o Honeywell Primus II RCZ Issue

2. ACRONYM LIST & GLOSSARY OF TERMS

2.1 ACRONYM LIST

ACID	Aircraft Identification
ADS-C	Automatic Dependent Surveillance - Contract
ADS-B	Automatic Dependent Surveillance - Broadcast
AIGD	ADS-B Implementation and Operations Guidance Document
AIP	Aeronautical Information Publication
AIT	ADS-B Implementation Team
AMSL	Above Mean Sea Level
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APRD	ADS-B Avionics Problem Reporting Database
ARINC	Aeronautical Radio 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
NACp	Navigation Accuracy Category
NIC	Navigation Integrity Category
PRS	Problem Reporting System
RAI	Restricted Area Intrusion
RAM	Route Adherence Monitoring
RAIM	Receiver Autonomous Integrity Monitoring
RFC	Request for Change
RNP	Required Navigation Performance
SIL	Source Integrity Level
SITF	Study and Implementation Task Force
STCA	Short Term Conflict Alert
SURICG	Surveillance Implementation Coordination Group

2.2 GLOSSARY OF TERMS

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

3. REFERENCE DOCUMENTS

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

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

4. ADS-B DATA

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

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

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

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

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

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

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

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

5. ADS-B IMPLEMENTATION

5.1 INTRODUCTION

5.1.1 Planning

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

5.1.2 Implementation team to ensure international coordination

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

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

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

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

5.1.3 System compatibility

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

5.1.3.2 Given the international nature of aviation, special efforts should be taken to ensure harmonization 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 ADS-B is one of the cost-effective means in complementing and overcoming limitations of Mode A/C radars, including false targets, aircraft positions temporarily not displayed and split tracks, which could cause aircraft display issues on radar screens for ATC irrespective of brands of Air Traffic Management System being used. Within busy airspace, aircraft could be managed at close lateral distance while vertically separated. In such situation, Mode A/C radars sometimes provide garbled detection, in the form of false targets due to overlapping replies from two or more aircraft. In the case of ADS-B, ADS-B data are broadcast in an omni-directional, random and periodic intervals without suffering from the same issue. In addition, automatic data validation is usually done at ADS-B receivers to ensure integrity of ADS-B information received from the aircraft.

5.1.4.4.3 A guidance material on issues to be considered in ATC multi-sensor fusion processing including integration of ADS-B data is provided on the ICAO website http://www.icao.int/APAC/Pages/edocs.aspx for reference by States.

5.1.4.4.4 Acquisition of Mode 3/A code for DO-260 aircraft through Mode S downlink

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

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

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

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

5.1.4.4.5 A guidance material on processing and displaying of ADS-B data at air traffic controller positions is provided on the ICAO website "http://www.icao.int/APAC/Pages/edocs.aspx" for reference by States.

5.1.4.4.6 Most of the ATC automation systems that support terrestrial ADS-B will also support space-based ADS-B without modifications. For more guidance, reference can be made to WP/12 on "ATC Automation Requirement and Space-based ADS-B" delivered during 3rd meeting of the SURICG.

5.1.4.5 Additional Functional Requirements for ADS-B Integration

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

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

- The system could include an adaptable Downlinked Aircraft Parameters (DAP) field that invokes a popup with the following information from Mode-S and ADS-B aircraft:
  - Magnetic Heading
  - True Track Angle
  - Indicated Airspeed/Mach Number
  - Groundspeed
  - Track Angle Rate
  - True Airspeed
  - Roll Angle
  - Selected Altitude
  - Vertical Rate

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

- The system could monitor[1] the ICAO Aircraft Address of individual aircraft and generate alert for the following cases:
  - ICAO Aircraft Address does not match with that specified in flight planICAO Aircraft Address is all 0 or F (expressed in hexadecimal)
  - ICAO Aircraft Address is not defined in ICAO's allocation
  - Duplicate ICAO Aircraft Address detected within single sensor in the same time-frame
  - Duplicate ICAO Aircraft Address detected within multi-sensors in the same time-frameICAO Aircraft Address changes during the flight
  - Aircrafts whose state identification number is not match with the state information registered in its flight plan
  - Aircrafts whose state identification number is not defined in SARPs (Annex 10)
  - Mode-S transponder of which P4 pulse was not detected
  - Mode-A/C transponder replied to Mode-S all call

5.1.5 Coverage Predictions

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

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

5.2 IMPLEMENTATION CHECKLIST

5.2.1 Introduction

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

5.2.2 Activity Sequence

The activities are listed in an approximate sequential order. However, each activity does not have to be completed prior to starting the next activity. In many cases, a parallel and iterative process should be used to feed data and experience from one activity to another. It should be noted that not all activities will be required for all applications.

5.2.3 Concept Phase

a) construct operational concept:

1) purpose;
2) operational environment;
3) ATM functions; and
4) infrastructure;

b) identify benefits:

1) safety enhancements;
2) efficiency;
3) capacity;
4) environmental;
5) cost reductions;
6) access; and
7) other metrics (e.g. predictability, flexibility, usefulness);

c) identify constraints:

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

d) prepare business case:

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

5.2.4 Design Phase

a) identify operational requirements:

1) security; and
2) systems interoperability;

b) identify human factors issues:

1) human-machine interfaces;
2) training development and validation;
3) workload demands;
4) role of automation vs. role of human;
5) crew coordination/pilot decision-making interactions; and
6) ATM collaborative decision-making;

c) identify technical requirements:

1) standards development;
2) prevailing avionics standards;
3) data required;
4) functional processing;
5) functional performance; and
6) required certification levels;

d) equipment development, test, and evaluation:

1) prototype systems built to existing or draft standards/specifications;
2) developmental bench and flight tests; and
3) acceptance test parameters; and
4) select and procure technology;

e) develop procedures:

1) pilot and controller actions and responsibilities;
2) phraseologies;
3) separation/spacing criteria and requirements;
4) controller's responsibility to maintain a monitoring function, if appropriate;
5) contingency procedures;
6) emergency procedures; and
7) develop AIP and Information documentation

f) prepare design phase safety case:
1) safety rationale;
2) safety budget and allocation; and
3) functional hazard assessment.

5.2.5 Implementation phase

a) prepare implementation phase safety case;

b) conduct operational test and evaluation:

1) flight deck and ATC validation simulations; and
2) flight tests and operational trials;

c) obtain systems certification:

1) aircraft equipment; and
2) ground systems;

d) obtain regulatory approvals:

1) air traffic certification of use;

e) implementation transition:

1) Promulgate procedures and deliver training
2) continue data collection and analysis;
3) resolve any unforeseen issues; and
4) continue feedback into standards development processes;

f) performance monitoring to ensure that the agreed performance is maintained.

5.2.5.1 Once the implementation project is complete, ongoing maintenance and upgrading of both ADS-B operations and infrastructure should continue to be monitored, through the appropriate forums.

6. HARMONIZATION FRAMEWORK FOR ADS-B IMPLEMENTATION

6.1 BACKGROUND

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

6.1.2 It is considered that the above implementation framework for ATS routes L642/M771 would serve as a useful template for extension to other high density routes to harmonize ADS-B implementation. Paragraph 6.2 shows the detailed framework.

6.2 TEMPLATE OF HARMONIZATION FRAMEWORK FOR ADS-B IMPLEMENTATION

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

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

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

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

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

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

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

The following recommendations need to be considered:

1. Whether complex or not, States are urged to consider whether the current or required surveillance system performance is better, equivalent or worse than the SASP reference.

2. If the current or required surveillance system used by a State is lower or equivalent in performance than the reference MSSR used in Circular 326 Appendix A, then that State may use the Appendix C performance criteria.

3. If the current or required surveillance system used by a State is higher performance than the reference MSSR used in Circular 326 Appendix A, then the State must ensure that the ADS-B system achieves the more demanding performance.

4. State should undertake, in all cases, a safety assessment that ensures that any additional risks and safety requirements already identified for the airspace where ADSB or MLAT is to be implemented, or any newly identified risks, are effectively controlled and risk is reduced to an acceptable level.

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

7.4 ATC SYSTEM VALIDATION

7.4.1 Safety Assessment Guidelines

To meet system integrity requirements, States should conduct a validation process that confirms the integrity of their equipment and procedures. Such processes shall include:

a) A system safety assessment for new implementations is the basis for definitions of system performance requirements. Where existing systems are being modified to utilize additional services, the assessment demonstrates that the ATS Provider's system will meet safety objectives;

b) Integration test results confirming interoperability for operational use of airborne and ground systems; and

c) Confirmation that the ATS Operation Manuals are compatible with those of adjacent providers where the system is used across a common boundary.

7.4.2 System safety assessment

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

a) Identifying failure conditions;

b) Assigning levels of criticality;

c) Determining risks/ probabilities for occurrence;

d) Identifying mitigating measures and fallback arrangements;

e) Categorising the degree of acceptability of risks; and

f) Operational hazard ID process.

Following the safety assessment, States should institute measures to offset any identified failure conditions that are not already categorized as acceptable. This should be done to reduce the probability of their occurrence to a level as low as reasonably practicable. This could be accomplished through system automation or manual procedures.

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

7.4.3 Integration test

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

7.4.4 ATS Operation Manuals

States should coordinate with adjacent States to confirm that their ATS Operation Manuals contain standard operating procedures to ensure harmonization of procedures that impact across common boundaries.

7.4.5 ATS System Integrity

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

a) A conservative approach is taken to manage any changes to the system;

b) Aircrew, aircraft operating companies and adjacent ATSU(s) are notified of any planned system changes in advance, where that system is used across a common boundary;

c) ATSUs have verification procedures in place to ensure that following any system changes, displayed data is both correct and accurate;

d) In cases of system failures or where upgrades (or downgrades) or other changes may impact surrounding ATS units, ATSUs should have a procedure in place for timely notification to adjacent units. Such notification procedures will normally be detailed in Letters of Agreement between adjacent units; and

e) ADS-B surveillance data is provided with equal to or better level of protection and security than existing surveillance radar data.

7.5 SYSTEM MONITORING

During the initial period of implementation of ADS-B technology, routine collection of data is necessary in order to ensure that the system continues to meet or exceed its performance, safety and interoperability requirements, and that operational service delivery and procedures are working as intended. The monitoring program is a two-fold process. Firstly, summarised statistical data should be produced periodically showing the performance of the system. This is accomplished through ADS-B Periodic Status Reports. Secondly, as problems or abnormalities arise, they should be identified, tracked, analyzed and corrected and information disseminated as required, utilizing the ADS-B Problem Report.

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

7.5.1 Problem Reporting System (PRS)

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

The PRS Administrator shall:

a) prepare consolidated problem report summaries for each SURICG meeting;

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

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

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

7.5.2 The monitoring process

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

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

a) ATS Providers;

b) Organizations responsible for ATS system maintenance (where different from the ATS provider);

c) Relevant State regulatory authorities;

d) Communication Service Providers being used;

e) Aircraft operators; and

f) Aircraft and avionics manufacturers.

7.5.3 Distribution of confidential information

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

7.5.4 ADS-B problem reports

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

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

a) Re-training of system operators, or revision of training procedures to ensure compliance with existing procedures;

b) Change to operating procedures;

c) Change to system requirements, including performance and interoperability; or

d) Change to system design.

7.5.5 ADS-B periodic status report

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

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

7.5.6 Processing of Reports

Each group in the monitoring process should nominate a single point of contact for receipt of problem reports and coordination with the other parties. This list will be distributed by the PRS Administrator to all parties to the monitoring process.
Each State should establish mechanisms within its ATS Provider and regulatory authority to:

a) Assess problem reports and refer them to the appropriate technical or operational expertise for investigation and resolution;

b) Coordinate with aircraft operators;

c) Develop interim operational procedures to mitigate the effects of problems until such time as the problem is resolved;

d) Monitor the progress of problem resolution;

e) Prepare a report on problems encountered and their operational implications and forward these to the PRS;

f) Prepare the ADS-B periodic status report at pre-determined times and forward these to the Secretary of the annual meeting of the SURICG; and

g) Coordinate with any Communication Service Providers used.

7.6 APANPIRG

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

a) review Periodic Status Reports and any significant Problem Reports;

b) highlight successful problem resolutions to SURICG members;

c) monitor the progress of outstanding problem resolutions;

d) prepare summaries of problems encountered and their operational implications; and

e) assess system performance based on information in the PRS and Periodic Status Reports.

7.7 LOCAL DATA RECORDING AND ANALYSIS

7.7.1 Data recording

It is recommended that ATS Providers and Communication Service Providers retain the records defined below for at least 30 days to allow for accident/incident investigation processes. These records should be made available on request to the relevant State safety authority. Where data is sought from an adjacent State, the usual State to State channels should be used.

These recordings shall be in a form that permits a replay of the situation and identification of the messages that were received by the ATS system.

7.7.2 Local data collection

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

7.7.3 Avionics problem identification and correction

ATS providers need to develop systems to:

a) detect ADS-B avionics anomalies and faults

b) advise the regulators and where appropriate the aircraft operators on the detected ADS-B avionics anomalies and faults

c) devise mechanisms and procedures to address identified faults

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

7.8 ADS-B PROBLEM REPORT

7.8.1 Report Form			**PRS #**
Start Time/Date UTC		**End Time/Date UTC**	
Registration		**Aircraft ID**	
Flight ID		**ICAO Aircraft Address**	
Aircraft Type			
Flight Sector/ Location			
ATS Unit			
Description / additional information			
Originator		**Originator Reference number**	
Organization			

7.8.2 Description of Fields

Field	Meaning
Number	A unique identification number assigned by the PRS Administrator to this problem report. Organizations writing problem reports are encouraged to maintain their own internal list of these problems for tracking purposes. Once the problems have been reported to the PRS and incorporated in the database, a number will be assigned by the PRS and used for tracking by the SURICG.
Start Time/Date UTC	UTC time/date when the event occurred.
End Time/Date UTC	UTC time/date when the event ended.
Registration	Registration number (tail number) of the aircraft involved.
Aircraft ID (ACID)	Coded equivalent of voice call sign as entered in FPL Item 7.
ICAO Aircraft Address	Unique ICAO Aircraft Address expressed in Hexadecimal form (e.g. 7432DB)
Flight ID (FLTID)	The identification transmitted by ADS-B for display on a controller situation display or a CDTI.
Flight Sector/Location	The departure airport and destination airport for the sector being flown by the aircraft involved in the event. These should be the ICAO identifiers of those airports. Or if more descriptive, the location of the aircraft during the event.
Originator	Point of contact at the originating organization for this report (usually the author).
Aircraft Type	The aircraft model involved.
Organization	The name of the organization (airline, ATS provider or communications service provider) that created the report.
ATS Unit	ICAO identifier of the ATC Center or Tower controlling the aircraft at the time of the event.
Description	This should provide as complete a description of the situation leading up to the problem as is possible. Where the organization reporting the problem is not able to provide all the information (e.g. the controller may not know everything that happens on the aircraft), it would be helpful if they would coordinate with the other parties to obtain the necessary information. The description should include: • A complete description of the problem that is being reported • The route contained in the FMS and flight plan • Any flight deck indications • Any indications provided to the controller when the problem occurred • Any additional information that the originator of the problem report considers might be helpful but is not included on the list above If necessary to contain all the information, additional pages may be added. if the originator considers it might be helpful, diagrams and other additional information (such as printouts of message logs) may be appended to the report.

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" at **Appendix 6**.

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

(a) Tier 1 standards are for a high performance traffic separation service;

(b) Tier 2 standards are for a traffic situational awareness service with procedural separation; and

(c) Tier 3 standards are for a traffic advisory service (flight information service)

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

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

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

8.1 Reliability

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

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

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

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

Difficulties can be experienced if States :

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

Spares pool

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

Module repair contract

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

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

The advantages of a module repair contract are:

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

Other typical strategies are:

- Establish availability and reliability objectives that are agreed organization wide. In particular agree System response times (SRT) for faults and system failure to ensure that MDT is achieved. An agreed SRT can help organizations to decide on the required logistics strategy including number, location and skills of staff to support the system.

- Establish baseline preventative maintenance regimes including procedures and performance inspections in conjunction with manufacturer recommendations for all subsystems

- Use remote control & monitoring systems to identify faulty modules before travel to site. This can avoid multiple trips to site and reduce the repair time

- Have handbooks, procedures, tools available at the site or a nearby depot so that travel time does not adversely affect down time

- Have adequate spares and test equipment ready at a maintenance depot near the site or at the site itself. Vendors can be required to perform analysis of the number of spares required to achieve low probability of spare “stock out”

- Have appropriate plans to cope with system and component obsolescence. It is possible to contractually require suppliers to regularly report on the ability to support the system and supply components.

- Have ongoing training programs and competency testing to ensure that staff are able to perform the required role

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

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

- Having clear organizational & individual responsibilities and accountabilities for system configuration.

- Having clear procedures in place which define who has authority to change configuration and records of the changes made including, inter alia
  - The nature of the change including the reason

- Impact of the change & safety assessment
- An appropriate transition or cutover plan
- Who approved the change
- When the change was authorized and when the change was implemented

- Having appropriate test and analysis capabilities to confirm that new configurations are acceptable before operational deployment.

- Having appropriate methods to deploy the approved configuration (Logistics of configuration distribution). Suggested methods;

  - Approved configuration published on intranet web pages
  - Approved configuration distributed on approved media

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

- Conduct of appropriate Training Needs Analysis (TNA) to identify the gap between trainee skill/knowledge and the required skill/knowledge.

- Development and delivery of appropriate training to maintainers

- Competency based testing of trainees

- Ongoing refresher training to ensure that skills are maintained even when fault rates are low

E: Data collection & Review :

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

- Reports of actual achieved availability & reliability

- Data regarding system failures including "down time" needs to be captured and analysed so the ANSP actually knows what is being (or not being) achieved.

- Any failure trends that need to be assessed. This requires data capture of the root cause of failures

- Any environmental impacts on system performance, such coverage obstructions such as trees, planned building developments, corrosion, RFI etc. Changes in infrastructure may also be relevant including air conditioning (temperature/humidity etc.) and power system changes.

- System problem reports especially those that relate to software deficiencies (design)

- System and component obsolescence

- Staff skills and need for refresher training

9. ADS-B REGULATIONS AND PROCEDURES

9.1 INTRODUCTION

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

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

9.2 ADS-B REGULATIONS

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

(a) mandating the carriage and use of ADS-B equipment; or

(b) providing priority for access to such airspace for aircraft with operative ADS-B equipment over those aircraft not operating ADS-B equipment.

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

- define the ADS-B standards applicable to the State. For interoperability and harmonization, such regulations need to define both the standards applicable for the aircraft ADS-B position source and the ADS-B transmitter.

- define the airspace affected by the regulations and the category of aircraft that the regulation applies to.

- define the timing of the regulations allowing sufficient time for operators to equip. Experience in Asia Pacific Regions is that major international carriers are having high 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 Compilation No. 4) 2014, Civil Aviation Order 82.1 (Compilation No. 13) ,
Civil Aviation Order 82.3 (No. 18), Civil Aviation Order 82.5 (No. 19)
https://www.legislation.gov.au/Details/F2017C01115/Download"

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

(c) Civil Aviation Authority of Singapore (CAAS)
Aeronautical Information Publication (eAIP) Part 2 ENR 1.8 – Regional Supplementary Procedures – Section 7 – Automatic Dependent Surveillance Broadcast (ADS-B) Out exclusive airspace within parts of the Singapore FIR
"https://fpl-1.caasaim.gov.sg/aip/2018-03-14/final/2018-03-14/html/index-en-GB.html"

(d) Federal Aviation Administration (FAA)
ADS–B Out Performance Requirements To Support Air Traffic Control (ATC) Service, Final Rule
http://www.gpo.gov/fdsys/pkg/FR-2010-05-28/pdf/2010-12645.pdf

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

9.3 FACTORS TO BE CONSIDERED WHEN USING ADS-B

9.3.1 Use of ADS-B Level data

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

9.3.2 Position Reporting Performance

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

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

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

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

9.3.3 GNSS Integrity Prediction Service

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

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

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

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

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

(a) ADS-B separation should not be applied by ATC to the particular aircraft reporting until the integrity has been assured; and

(b) The controller should check with other aircraft in the vicinity of the aircraft reporting the RAIM warning, to determine if they have also been affected and establish alternative forms of separation if necessary.

9.3.4 Sharing of ADS-B Data

ADS-B Data-sharing for ATC Operations

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

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

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

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

ADS-B Data-sharing for Safety Monitoring

With endorsement of the methodology by both the ICAO Separation and Airspace Safety Panel (SASP) and the Regional Airspace Safety Monitoring Advisory Group (RASMAG), ADS-B data can be used for calculating the altimetry system error (ASE) which is a measure of the height-keeping performance of an aircraft. It is an ICAO requirement that aircraft operating in RVSM airspace must undergo periodic monitoring on height-keeping performance. The existing methods to estimate aircraft ASE include use of a portable device, the Enhanced GPS Monitoring Unit, and ground-based systems called Height Monitoring Unit/Aircraft Geometric Height Measurement Element. The use of ADS-B data for height-keeping performance monitoring, on top of providing enhanced and alternative means of surveillance, will provide a cost-effective option for aircraft operators. States are encouraged to share ADS-B data to support the height-keeping performance monitoring of airframe.

Civil/Military ADS-B Data-sharing

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

Aircraft operating ADS-B technology transmit their position, altitude and identity to all listeners, conveying information from co-operative aircraft that have chosen to equip and publicly broadcast ADS-B messages. Thus there should be no defence or national security issues with the use and sharing of such data.

Some military transponders may support ADS-B using encrypted DF19 messages, but these data are normally not decoded or used at all by civil systems. In most cases today, tactical military aircraft are not ADS-B equipped or could choose to disable transmissions. In future, increasing numbers of military aircraft will be ADS-B capable, with the ability to disable these transmissions. ADS-B data sharing should not influence the decision by military authorities to equip or not equip with ADS-B. Moreover, it is possible for States to install ADS-B filters that prevent data from sensitive flights being shared. These filters can be based on a number of criteria and typically use geographical parameters to only provide ADS-B data to an external party if aircraft are near the boundary.

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

9.3.5 Synergy of ADS-B and GNSS

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

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

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

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

– a single design activity instead of two

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

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

9.3.6 Use of ADS-B for Airport Surface Movement

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

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

- DO260
  - NUCp > 6

- DO260A
  - NACp ≥ 8
  - NIC > 0
  - SIL = 2

- DO260B
  - NACp ≥ 8
  - NIC > 0
  - SIL = 3

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

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

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

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

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

9.4 Reporting Rates

9.4.1 General

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

9.5 SEPARATION

9.5.1 General

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

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

9.5.2 Identification Methods

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

a) direct recognition of the aircraft identification in an ADS-B label on a situation display;

b) transfer of ADS-B identification;

c) observation of compliance with an instruction to TRANSMIT ADS-B IDENT.

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

9.5.3 ADS-B Separation

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

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

9.5.4 Vertical separation

9.5.4.1 Introduction

The ADS-B level data presented on the controllers situation display shall normally be derived from barometric pressure altitude. In the event that barometric altitude is absent, geometric altitude shall not be displayed on displays used for provision of air traffic services. Geometric altitude may be used in ATM systems for other purposes.

9.5.4.2 Vertical tolerance standard

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

9.5.4.3 Verification of ADS-B level information

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

9.6 AIR TRAFFIC CONTROL CLEARANCE MONITORING

9.6.1 General

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

9.6.2 Deviations from ATC clearances

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

9.7 ALERTING SERVICE

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

9.8 POSITION REPORTING

9.8.1 Pilot position reporting requirements in ADS-B coverage

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

9.8.2 Meteorological reporting requirements in ADS-B airspace

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

9.9 PHRASEOLOGY

9.9.1 Phraseology Standard

States should use common phraseology for both ADS-B and radar where possible, and should note the requirement for ADS-B specific phraseology in some instances. States shall refer to PANS ATM Chapter 12 for ADS-B phraseology:
ADS-B EQUIPMENT DEGRADATION
ADS-B OUT OF SERVICE (appropriate information as necessary).

TO REQUEST THE CAPABILITY OF THE ADS-B EQUIPMENT

a) ADVISE ADS-B CAPABILITY;
*b) ADS-B TRANSMITTER (data link);
*c) ADS-B RECEIVER (data link);
*d) NEGATIVE ADS-B.
* Denotes pilot transmission.

Note: For (b) and (c) – the options are not available for aircraft that are not equipped.

TO REQUEST RESELECTION OF AIRCRAFT IDENTIFICATION
REENTER FLIGHT IDENTIFICATION.

Note: For some aircraft, this option is not available in-flight

TERMINATION OF RADAR AND/OR ADS-B SERVICE
IDENTIFICATION LOST [reasons] (instructions).

TO REQUEST THE OPERATION OF THE MODE S OR ADS-B IDENT FEATURE
SQUAWK IDENT.

Note: For some standalone ADS-B equipage affecting General Aviation, the option of "TRANSMIT ADS-B IDENT" may be available

TO REQUEST AIRCRAFT SWITCHING TO OTHER TRANSPONDER OR TERMINATION OF ADS-B TRANSMITTER OPERATION

a) SWITCH TO OTHER TRANSPONDER
b) STOP ADS-B TRANSMISSION. SQUAWK (code) ONLY.

Note:

a) In many cases the ADS-B transmitter cannot be operated independently of the SSR transponder and switching off the ADS-B transmission would also switch off the SSR transponder operation

b) "STOP ADS-B TRANSMISSION" applies only to aircraft that have the facility to switch off the ADS-B transmission, while maintaining SSR operation.

9.9.2 Operations of Mode S Transponder and ADS-B

It should be noted that independent operations of Mode S transponder and ADS-B will not be possible in many aircraft (e.g. where ADS-B is solely provided by 1090 MHz extended squitter emitted from the transponder). Additionally, some desirable but optional features of ADS-B transmitters may not be fitted in some aircraft. Controller training on this issue, as it relates to the following examples of radio telephony and/or CPDLC phraseology is recommended.

9.9.2.1 STOP ADSB TRANSMISSION or STOP SQUAWK

Issue: In most commercial aircraft, a common "transponder control head" is used for SSR transponder, ACAS and ADS-B functionality. In this case, a pilot who complies with the instruction to stop operation of one system will also need to stop operation of the other systems – resulting in a loss of surveillance not intended or expected by the controller.

ATC need to be aware that an instruction to "Stop ADS-B Transmission" may require the pilot to switch off their transponder that will then stop all other functions associated with the transponder operations (such as ACARs etc). Pilots need to be aware of their aircraft's equipment limitations, the consequences of complying with this ATC instruction, and be aware of their company policy in regard to this. As with any ATC instruction issued, the pilot should advise ATC if they are unable to comply.

Recommendation: It is recommended that the concatenated phrases STOP ADSB TRANSMISSION, SQUAWK (code) ONLY or STOP SQUAWK, TRANSMIT ADSB ONLY are used. It is recommended that controller training highlights the possible consequences of **issuing** these instructions and that pilot training highlights the consequences of **complying** with this instruction. It is also recommended that aircraft operators have a clearly stated policy on procedures for this situation. Should a pilot respond with UNABLE then the controller should consider alternative solutions to the problem that do not remove the safety defences of the other surveillance technologies. This might include manual changes to flight data, coordination with other controllers and/or change of assigned codes or callsigns.

Very few aircraft provide the capability to turn off ADS-B without turning off TCAS. It is not recommended to switch off ATC transponders (& remove TCAS protection). The only action for most pilots of aircraft transmitting misleading ADS-B data in response to ATC requests is to recycle the transponder, or switch to the alternate transponder as appropriate. Besides, aircraft that do not support ADS-B OFF should have the details included in the flight manual including the undesirability of disabling TCAS.

9.9.2.2 STOP ADSB ALTITUDE TRANSMISSION [WRONG INDICATION or reason] and TRANSMIT ADSB ALTITUDE

Issue: Most aircraft will not have separate control of ADSB altitude transmission. In such cases compliance with the instruction may require the pilot to stop transmission of all ADSB data and/or Mode C altitude – resulting in a loss of surveillance not intended or expected by the controller.

Recommendation: It is recommended that, should the pilot respond with UNABLE, the controller should consider alternative solutions to the problem that do not remove the safety defences of other surveillance data. This might include a procedure that continues the display of incorrect level information but uses pilot reported levels with manual changes to flight data and coordination with other controllers.

9.9.2.3 TRANSMIT ADS-B IDENT

Issue: Some aircraft may not be capable or the ADSB SPI IDENT control may be shared with the SSR SPI IDENT function.

Recommendation: It is recommended that controllers are made aware that some pilots are unable to comply with this instruction. An alternative means of identification that does not rely on the ADSB SPI IDENT function should be used.

9.10 FLIGHT PLANNING

9.10.1 ADS-B Flight Planning Requirement – Flight Identity

The aircraft identification (ACID) must be accurately recorded in section 7 of the ICAO Flight Plan form as per the following instructions:

Aircraft Identification, not exceeding 7 characters is to be entered both in item 7 of the flight plan and replicated exactly when set in the aircraft (for transmission as Flight ID) as follows:
Either,

a) The ICAO three-letter designator for the aircraft operating agency followed by the flight identification (e.g. KLM511, BAW213, JTR25), when:

in radiotelephony the callsign used consists of the ICAO telephony designator for the operating agency followed by the flight identification (e.g. KLM 511, SPEEDBIRD 213, HERBIE 25).

Or,

b) The registration marking of the aircraft (e.g. EIAKO, 4XBCD, OOTEK), when:

1) in radiotelephony the callsign used consists of the registration marking alone (e.g. EIAKO), or preceded by the ICAO telephony designator for the operating agency (e.g. SVENAIR EIAKO),

2) the aircraft is not equipped with radio.

Note 1: No zeros, hyphens, dashes or spaces are to be added when the Aircraft Identification consists of less than 7 characters.

Note 2: Appendix 2 to PANS-ATM refers. ICAO designators and telephony designators for aircraft operating agencies are contained in ICAO Doc 8585.

9.10.2 ADS-B Flight Planning Requirements

9.10.2.1 ICAO Flight Plan Item 10 – Surveillance Equipment and Capabilities

An appropriate ADS-B designator shall be entered in item 10 of the flight plan to indicate that the flight is capable of transmitting ADS-B messages.

These are defined in ICAO DOC 4444 as follows:

B1 ADS-B with dedicated 1090 MHz ADS-B “out” capability
B2 ADS-B with dedicated 1090 MHz ADS-B “out” and “in” capability
U1 ADS-B “out” capability using UAT
U2 ADS-B “out” and “in” capability using UAT
V1 ADS-B “out” capability using VDL Mode 4
V2 ADS-B “out” and “in” capability using VDL Mode 4

During the ADS-B SITF/13 meeting held in April 2014, clarification of the B1 and B2 descriptors was recommended as follows. This will be progressed for change to ICAO DOC 4444, but may take some time for formal adoption:

B1 ADS-B “out” capability using 1090 MHz extended squitter
B2 ADS-B “out” and “in” capability using 1090 MHz extended squitter

States should consider use of the revised descriptors in AIP.

9.10.2.2 ICAO Flight Plan Item 18 – Other Information

Where required by the appropriate authority the ICAO Aircraft Address (24 Bit Code) may be recorded in Item 18 of the ICAO flight plan, in hexadecimal format as per the following example:

CODE/7C432B

States should note that use of hexadecimal code may be prone to human error and is less flexible in regard to airframe changes for a notified flight.

9.10.2.3 Transponder Capabilities

When an aircraft is equipped with a mode S transponder, that transmits ADS-B messages, according to ICAO Doc 4444, an appropriate Mode S designator should also be entered in item 10; i.e.: either 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 NACp or the SIL by an aircraft indicates a navigational uncertainty related to the position of the aircraft or a navigation integrity issue that is too significant to be used by air traffic controllers.

As such, the following procedure currently stipulated in the Regional Supplementary Procedures Doc 7030[3], 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] SURICG/2 recommended States/Administrations to update their ADS-B Avionics Equipage Requirements to align with the template in Appendix 3

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 NACp or SIL

States may elect to implement a scheme to blacklist those non-compliant aircraft or aircraft consistently transmitting mis-leading ADS-B information, so as to refrain the aircraft from being displayed to ATC. Please refer Appendix 2 for guidance in implementing the blacklist scheme.
A sample template is given below for reference by States to publish the procedures to handle non-compliant ADS-B aircraft or misleading ADS-B transmissions in their ADS-B mandate/regulations:

After <insert earliest date that ADS-B may be used for any relevant operational purpose> if an aircraft carries ADS-B transmitting equipment which does not comply with :

(a) European Aviation Safety Agency - Certification Considerations for the Enhanced ATS in Non-Radar Areas using ADS-B Surveillance (ADS-B-NRA) Application via 1090 MHZ Extended Squitter (AMC 20-24), or
(b) European Aviation Safety Agency - Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance Subpart D — Surveillance (SUR) (CS-ACNS.D.ADS-B), or
(c) Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems, or
(d) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.

or the aircraft ADS-B transmitting equipment becomes unserviceable resulting in the aircraft transmitting misleading information;

the aircraft must not fly unless equipment is:

(a) deactivated; or

(b) set to transmit only a value of zero for the NUCp or NIC or NACp or SIL.

Note:

1. It is considered equivalent to deactivation if NUCp or NIC or NACp or SIL is set to continually transmit only a value of zero.

2. Regulators should take appropriate action to ensure that such regulations are complied with.

3. ATC systems should discard ADS-B data when NUC or NIC or NACp or SIL =0.

9.12 EMERGENCY PROCEDURES

ATC surveillance systems should provide for the display of safety-related alerts and warnings, including conflict alert, minimum safe altitude warning, conflict prediction and unintentionally duplicated SSR codes and aircraft identifications.

The ADS-B avionics may transmit emergency status messages to any ADS-B ground station within coverage. The controller receiving these messages should determine the nature of the emergency, acknowledge receipt if appropriate, and initiate any assistance required. An aircraft equipped with ADS-B might operate the emergency and/or urgency mode as follows:

a) emergency;
b) no communications;
c) unlawful interference;
d) minimum fuel; and/or
e) medical.

Selection of an emergency transponder code (e.g. 7600) automatically generates an emergency indication in the ADS-B message. However, some ADS-B transponders may only generate a generic emergency indication. That means, the specific type of emergency, e.g., communication failure, is not always conveyed to the controller in an ADS-B environment. The controller may only receive a generic emergency indication irrespective of the emergency codes being selected by the pilot.

In some early ADS-B avionics configurations, when a generic emergency indication is being transmitted, a request to "Transmit ADS-B Ident" or "Squawk Ident" may not result in the Ident indication being displayed in the ATC System. This is because the emergency and ident flags share the same data elements in the ADS-B downlink message.

Due to limitations of some ADS-B transponders, procedures should be developed for ATC to confirm the types of emergency with pilots based on operational needs of States.

In contrast to DO260 avionics, for DO-260A avionics, the transmission of an Emergency/Priority status message in the ADS-B message set will also include the original MODE A code allocated by ATC. When the aircraft resets the MODE A code to the original allocated code the ground station can retain the Emergency/Priority status in the Asterix message, for up to 100 seconds, even though the aircraft is no longer squawking an emergency code. This situation can generate confusion as to the actual status of the aircraft.

Executive control responsibility

The responsibility for control of the flight rests with the ATSU within whose airspace the aircraft is operating. However, if the pilot takes action contrary to a clearance that has already been coordinated with another sector or ATSU and further coordination is not possible in the time available, the responsibility for this action would rest with the pilot in command, and performed under the pilot's emergency authority.

Emergency procedures

The various circumstances surrounding each emergency situation preclude the establishment of exact detailed procedures to be followed. The procedures outlined in PANS-ATM Chapter 15 provide a general guide to air traffic services personnel and where necessary, should be adapted for the use of ADS-B.

9.13 PROCEDURES TO HANDLE GPS TIME AND WEEK COUNTER ROLLOVER

The GPS system is often used in the ATC environment, including:

- to time stamp surveillance data with the "time of applicability" of the data. This allows positional data to be "extrapolated" to the time of display and allows old data to be discarded.
- to time synchronise ATC systems to the correct time, so that when it uses surveillance data, it can determine the "age" of the data.
- to time stamp recorded data and maintenance data

Thus accurate time is important to minimise incorrect positional data being presented to ATC and to ensure that valid data is not discarded – amongst other important technical roles in synchronising various computer servers in a network.

9.13.1 GPS TIME – COUNTERS AND LEAP SECONDS

The GPS navigation message contains information about the current date and time in the form of a sequential week counter (representing the number of weeks elapsed since the last time this counter was reset to zero). This counter is 10 bits long and this resets to zero every 1024 weeks (19.6 years). GPS week zero started at 00:00:00 UTC on January 6, 1980, and the week number became zero again on August 21, 1999. A rollover event occurred on 6 April 2019.

ATC systems use UTC. The difference between GPS time and UTC changes whenever a "leap second" is inserted in UTC. Wikipedia says that "one-second adjustment that is occasionally applied to civil time Coordinated Universal Time (UTC) to keep it close to the mean solar time at Greenwich, in spite of the Earth's rotation slowdown and irregularities". This is done in coordination with the international community.

The GPS messages sent by the satellites includes the difference between GPS time and UTC, thus allowing the GPS receivers to calculate UTC.

9.13.2 GPS RECEIVER ISSUES

Each GPS receiver has firmware/software that computes UTC from the GPS time counters and from the known offset. In the past some GPS receivers have not coped well with these changes. The triggers occur very infrequently and in some cases they have not been adequately tested.

This can cause incorrect UTC time to be output following some events such as:

- Software deficiencies highlighted by the week number rollover. The rollover occurs each 19.6 years

- Deficiencies at leap second introductions (at intervals greater than 1 year)

- Loss of GPS-UTC time offset (sometimes at power off in devices not using non-volatile storage). Typically this can result in up to 15 minutes of incorrect time data until the offset is restored from the satellite messages.

Other problems such as receiver lock up (service failure) can occur when the GPS receiver is exposed to rare real world events or stimuli.

9.13.3 ATC SYSTEM RISKS AND MITIGATION

ANSPs and regulators need to be aware of the potential issues that may arise from GPS receivers that inadequately process events and stimuli.

Possible mitigations that could be considered include:

- Testing GPS receivers with a GPS test tool that simulates possible events/ stimuli
- Co-ordination with GPS receiver manufacturers
- Disconnect GPS receivers just before expected events – and check the output before reconnecting the GPS receiver. (in this case the ANSP would be relying on the ability of the ATC or surveillance system to operate for a period without the GPS synchronisation).

10. SECURITY ISSUES ASSOCIATED WITH ADS-B

10.1 INTRODUCTION

ADS-B technologies are currently "open systems" and the openness is an essential component of successful use of ADS-B. It was also noted that ADS-B transmission from commercial aircraft is a "fact of life" today. Many commercial aircraft are already equipped with ADS-B and have been transmitting data for some time.

It was noted that there has been considerable alarmist publicity regarding ADS-B security. To a large extent, this publicity has not considered the nature and complexity of ATC. Careful assessment of security policies in use today for ADS-B and other technologies can provide a more balanced view.

10.2 CONSIDERATIONS

A list of ADS-B vulnerabilities categorised into threats to Confidentiality, Integrity and Availability has been reviewed and documented into the guidance material on security issues associated with ADS-B provided on the ICAO APAC website "http://www.icao.int/APAC/Pages/edocs.aspx" under "Restricted Site" for reference by States. States could contact ICAO Regional Office to get access to the guidance material. The following recommendations are made to States :

(a) While ADS-B is recognized as a key enabling technology for aviation with potential safety benefits, it is recommended that States made aware of possible ADS-B security specific issues;

(b) It is recommended that States note that much of the discussion of ADS-B issues in the Press has not considered the complete picture regarding the ATC use of surveillance data;

(c) For current ADS-B technology implementation, security risk assessment studies should be made in coordination with appropriate national organisations and ANSPs to address appropriate mitigation applicable in each operational environment, in accordance with ATM interoperability requirements; and

(d) Future development of ADS-B technology, as planned in the SESAR master plan for example, should address security issues. Studies should be made to identify potential encryption and authentication techniques, taking into consideration the operational need of air to ground and air to air surveillance applications. Distribution of encryption keys to a large number of ADS-B receivers is likely to be problematic and solutions in the near and medium term are not considered likely to be deployed worldwide. Internet based encryption strategies are not deployable when ground stations are pass receivers.

10.3 MEASURES FOR ENHANCING THE SECURITY OF ADS-B

10.3.1 TIME DIFFERENCE OF ARRIVAL (TDOA) BASED POSITION VERIFICATION METHOD

One of the technologies for enhancing ADS-B security is TDOA-based position verifiation, which is able to mitigate false targets caused by spoofing. In a case of spoofing, the position of the emitter (attacker) is likely to differ from the position contained in the ADS-B signal. Such positional difference can be detected by means of TDOA.

When an emitter (aircraft or spoofing emitter) transmits an ADS-B signal, (at least) two receivers detect the signal and measure the time of arrival (TOA). The difference of the TOAs between the two receivers is a TDOA. Next, decoding the ADS-B signal obtains the position contained in the signal. A calculation using the ADS-B position and the known receiver positions obtains the expected TDOA.

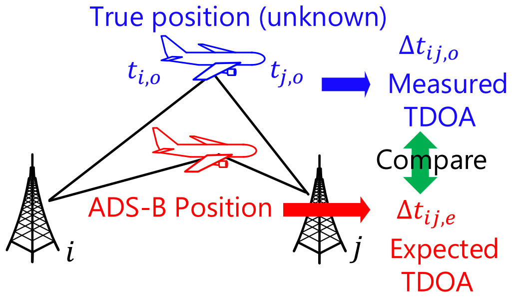

Figure 10.3.1.1 Illustration of the Procedures of TDOA method

The measured and expected TDOAs are compared. The TDOA difference is large in a case of spoofing and small in a case of a legitimate aircraft, as illustrated in Figure 10.3.1.2 (a) and (b), respectively. Therefore, a threshold can be used to make a decision; if the TDOA difference is smaller than the threshold, the position is determined as valid. If the TDOA difference is larger than the threshold, the position is determined as anomalous (spoofing).

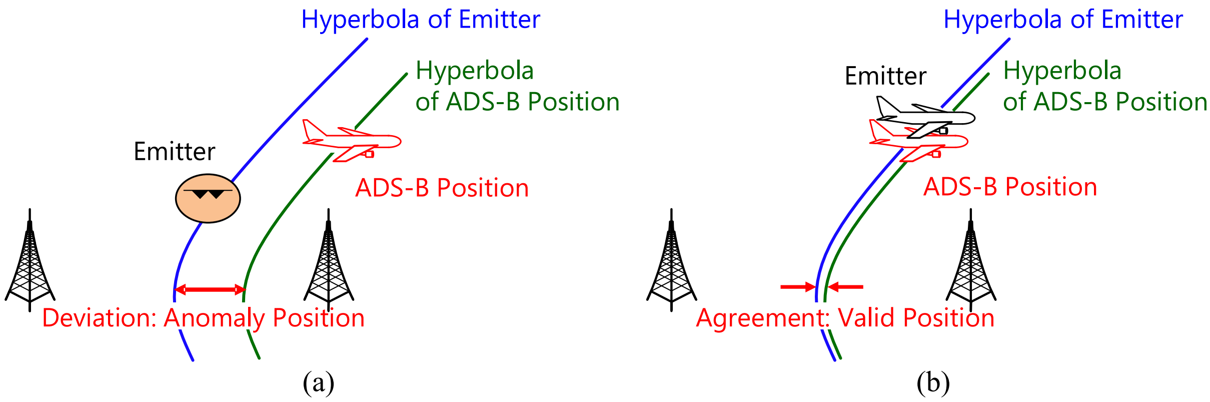

Figure 10.3.1.2 Illustration of (a) case of spoofing, and (b) case of legitimate aircraft

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Appendix 1

SYSTEM MANAGEMENT MANUAL
CHANGE CONTROL
C-FORMS0348

Commissioning Readiness

The requirement for this form is specified in the System Management Manual (Section 11.2 of V4), C-MAN0107		
Project/Task Name	**SAP Project/Task ID:**	**Sites or Locations affected:**
Documentation prepared by:	**Date:**	**Commissioning Date:**
Affected System(s)	**System Criticality**	**Change Consequence Level**
Brief Description of Change:		

Commissioning Readiness Endorsement

The endorsement of this form by the appropriate authorities as specified in the System Management Manual certifies that the requirements detailed in this form (with the exception of the non-critical deficiencies[1] listed herein) have been completed prior to the commissioning of the system change or new system.

Chief Engineer or Technical or Maintenance Authority

Name:	**Signature:**	**Date**:
Designation:		
Name:	**Signature:**	**Date**:
Designation:		

Chief Operating/User Authority or Operating/User Authority

Name:	**Signature:**	**Date**:
Designation:		

Records Management Instructions

Place the completed Commissioning Readiness Form, together with any support documents on the Project file

Provide a copy of the completed Commissioning Readiness Form to P&E, Asset Lifecycle Manager, Planning and Integration

Note 1: Non-critical deficiencies (NCD) are those outstanding technical and operational issues that do not prevent the safe and effective use or maintenance of the facility, but will be addressed in a specified and agreed time. NCDs shall be listed on the Commissioning Certificate (C-FORMS0300) and recorded in the relevant system (ASID / HEAT / SAIR). It is preferable for each NCD to be recorded as a separate Issue.

SYSTEM MANAGEMENT MANUAL
CHANGE CONTROL
C-FORMS0348

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
1	OPERATIONAL SAFETY			
1.1	Provide a link to the completed SCARD **SCARD** Template (AA-TEMP-SAF-0042) Note: For unregulated systems the SCARD shall be used to assess the impact of the change and perform a preliminary hazard analysis	Safety Change Management Requirements AA-NOS-SAF-0104	Completed ☐ N/A ☐	**Link to SCARD**
1.2	The outcome of the SCARD will be the requirement for one of the following for commissioning: **Safety Statement** – included in SCARD or standalone Safety Statement which must provide Airservices Australia management with sufficient information to demonstrate that safety has been considered and the change presents minimal or no safety issues. **Safety Plan & Safety Assessment Report, or** **Safety Plan & Safety Case** Safety Plans, Safety Assessment Reports and Safety Cases are required to be available in the Document Search Database	Safety Change Management Requirements AA-NOS-SAF-0104 Document Search Database	Completed ☐ N/A ☐	**Link to Safety statement or** **Link to Safety Plan & Safety Assessment Report or** **Link to Safety Plan & Safety Case**
1.3	Safety risk management process completed and includes • any new hazards / impact to existing hazards identified? • controls identified and in place? and • residual risk justified and accepted.	Safety Risk Management Procedures AA-PROC-SAF-0105	Completed ☐ N/A ☐	
1.4	Impacts on the Operational Risk Assessments from residual risks have been assessed and implemented using Operational Risk Assessment Change Request and Acceptance Record – AA-FORM-SAF-0032	Operational Risk Assessment AA-NOS-SAF-0006 Safety Risk Management Procedures AA-PROC-SAF-0105	Completed ☐ N/A ☐	Link to Operational Risk Assessment Change Request and Acceptance Record:
1.5	Arrangements for monitoring and review of risks are in place including arrangements for safety performance monitoring following the transition.	Safety Risk Management Procedures AA-PROC-SAF-0105	Completed ☐ N/A ☐	
1.6	CASA have approved / accepted or been advised of the change, as applicable	Safety Change Management Requirements AA-NOS-SAF-0104	Completed ☐ N/A ☐	

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Form approved by: Branch Manager, Operational Integrity & Compliance

Commercial in Confidence

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
2	WORKPLACE HEALTH & SAFETY			
2.1	Initial WHS Hazard Identification must be completed as per the template AA-TEMP-SAF-0020	Safety Risk Management Procedures AA-PROC-SAF-0105 Initial WHS Hazard Identification AA-TEMP-SAF-0020 Workplace Health and Safety Risk Management Summary AA-TEMP-SAF-0016	Completed ☐ N/A ☐	**Link to completed Workplace Health and Safety Management Summary** AA-TEMP-SAF-0016
2.2	Ensure employees and stakeholders are consulted when significant changes to work arrangements are being considered.	Working Together Workplace Consultation AA-PROC-SAF-0009	Completed ☐ N/A ☐	
2.3	Tower Access / Classification assessed? Working at Heights Safety Checklist & Daily Toolbox Meeting (F098) Fall arrest facility / equipment available	Working at Heights PROC-157 Working at Heights Safety Checklist & Daily Toolbox Meeting F098	Completed ☐ N/A ☐	
2.4	WHS hazard controls are in place - Safe Work Method Statement completed - Plant risks managed - Radhaz survey completed, published on the Avnet and general public & occupational exposure boundaries identified	Safe Work Method Statement AA-TEMP-SAF-0017 Managing WHS Risk for Contractors and Projects AA-PROC-SAF-0012 Plant Risk Management PROC-134 RF Radiation, Surveys & Health & Safety Mgmt PROC-121	Completed ☐ N/A ☐	**Link to completed Safe Work Method Statement** AA-TEMP-SAF-0017 **Link to completed** F131 **Plant Risk Management Checklist**
2.5	At the completion of works ensure WHS Inspections are completed and hazard controls are in place. Building condition; clean, undamaged, all work completed.	Conducting Workplace Safety Inspections AA-PROC-SAF-0008	Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
3	ENVIRONMENT			
3.1	Environmental Impact must be assessed using the Environmental Impact Screening & Assessment Criteria for Changes to On-ground Activities Assistance in assessing the Environmental Impact can be obtained from Environment and Climate Change Unit in Environment Group.	Environmental Screening & Assessment Criteria for Changes to On-ground Activities AA-REF-ENV-0010 Environmental Assessment of Changes to On-ground Activities. AA-NOS-ENV-2.200	Completed ☐ N/A ☐	**Link to completed Environmental Impact Screening and Assessment Form** **If a stage 2 assessment is required provide ARMS reference and links to any Permits, Master Development Plans and relevant correspondence as required.**
3.2	Environmental Clearance obtained for ATM changes as per AA-NOS-ENV-2.100 Assistance in assessing the Environmental Impact can be obtained from Environment and Climate Change Unit in Environment Group.	Environment Assessment Process for ATM Changes AA-NOS-ENV-2.100	Completed ☐ N/A ☐	**Provide ARMS reference and NRFC reference if ATM change required**
4	PEOPLE- SUPPORT			
ATC TRAINING				
4.1	ATC Training Needs Analysis completed and Training Plan developed?		Completed ☐ N/A ☐	**Link to Training Needs Analysis and Training Plan**
4.2	Sufficient number of trained, rated and endorsed ATC staff available.		Completed ☐ N/A ☐	**Number Trained:**
4.3	ATC staff individual training records in SAP database have been updated		Completed ☐ N/A ☐	
4.4	Plans are in place to complete any outstanding training, rating, and endorsement of remaining ATC staff (Normally an identified hazard)		Completed ☐ N/A ☐	**HAZLOG Register No:**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
TECHNICAL TRAINING				
4.5	Training Needs Analysis completed and Training Plan developed for system support staff and field maintenance staff?		Completed ☐ N/A ☐	**Link to Training Needs Analysis and Training Plan**
4.6	TechCert codes have been created, assessment criteria developed or existing assessment criteria has been amended	TechCert codes TechCert Guides and Forms	Completed ☐ N/A ☐	**Link to TechCert Guides and Forms**
4.7	Sufficient system support staff and field maintenance staff appropriately trained?		Completed ☐ N/A ☐	
4.8	Are plans are in place to complete any outstanding training and certification of system support staff and remaining field maintenance staff?		Completed ☐ N/A ☐	
4.9	Field maintenance staff hold the relevant TechCert to perform duties.	Technical Certification PROC-141	Completed ☐ N/A ☐	
4.10	Statutory / special licensing obtained by field maintenance staff including high risk work competencies and licensing requirements?		Completed ☐ N/A ☐	
4.11	ABS and FMS staff training details sent to Technical Training Coordinator and training records updated as required?	Training PROC-119	Completed ☐ N/A ☐	
4.12	TechCert details sent to FMS System Support to update the Qualifications (TechCert) Database	Technical Certification PROC-141	Completed ☐ N/A ☐	
LOGISTICAL SUPPORT				
4.13	CMRD have been consulted regarding special test equipment, test beds, etc		Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
4.14	CMRD / NDC have been consulted regarding spares holdings and repair of LRUs from this equipment or in-house support of Depot Level Support Contract / repair contract		Completed ☐ N/A ☐	
4.15	TEMACC advised of any specialised test equipment requirements.	Test Equipment Management PROC-150	Completed ☐ N/A ☐	
4.16	Maintenance support contracts in place (external and/or internal)? – Appropriate vendor and/or internal support? – Appropriate Level 3 maintenance arrangements		Completed ☐ N/A ☐	
4.17	Test equipment provided to maintenance base. Note: Test equipment purchasing and calibration requirements detailed in Engineering Execution Readiness form.		Completed ☐ N/A ☐	
4.18	Specialised hardware or software system support and field maintenance tools, test / patch leads, adaptors, isolators, electronic discharge protection (mats, straps), etc supplied?		Completed ☐ N/A ☐	
4.19	System Business Continuity/ Disaster Recovery provisions supplied/updated?		Completed ☐ N/A ☐	
4.20	Spares – Supplied, storage correct, transport cases supplied?	Management of Goods & Supplies PROC-118	Completed ☐ N/A ☐	
4.21	Spares – Software / firmware loaded, tested & configured?		Completed ☐ N/A ☐	
4.22	Service Restoration Times (SRT) established?	Airways Service Data PROC-207	Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
4.23	Conduct Hardware physical configuration audit and ensure SAP Plant Maintenance has updated information of all installed and/or demolished equipment (including monitoring circuits) and sent to System Operations SAP PM DATA CHANGES.	Equipment Installed/Demolished Advice SAP Data Input Form F104	Completed ☐ N/A ☐	**Link to Email from SAP PM Support confirming update/s**
5	PROCEDURES			
ATC DOCUMENTATION				
5.1	System Requirements documentation including Operating Concept or Business Process Rules - produced/updated and approved?		Completed ☐ N/A ☐	**Link to documentation**
5.2	Manual of Air Traffic Services (MATS) reviewed / updated. Aeronautical information publications (AIP Book, AIP SUPP, AIC, DAP, ERSA, Charts, etc) reviewed / updated. Amendment times are determined by the AIS Distribution Schedule	 AA Publications AIS Distribution Schedule	Completed ☐ N/A ☐	**NRFC No.**
5.3	National ATC Procedures Manual (NAPM) and any other relevant ATC procedures reviewed / updated.		Completed ☐ N/A ☐	**NRFC No.**
5.4	ATC contingency / continuity plans reviewed / updated.	ATS Contingency Plans Business Continuity Plans C-BCP	Completed ☐ N/A ☐	**ATS-CP No:** **C-BCP No:**
5.5	NOTAM and/or AIP SUP issued / amended / cancelled	Works Planning PROC-213 Refer also LOA3024	Completed ☐ N/A ☐	**NOTAM No:**
5.6	ATC Temporary Local Instruction (TLI) issued notifying Operational staff of change?	Temporary Local Instructions & Database	Completed ☐ N/A ☐	**NRFC No.**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
USER DOCUMENTATION				
5.7	User/operator manuals updated		Completed ☐ N/A ☐	
5.8	User/operator procedures provided/updated as applicable		Completed ☐ N/A ☐	
5.9	On-line user/operator documentation completed and published		Completed ☐ N/A ☐	
5.10	ARFF instructions updated		Completed ☐ N/A ☐	
5.11	Other Business Groups instructions updated?		Completed ☐ N/A ☐	
TECHNICAL DOCUMENTATION				
5.12	Software design documents updated, adequate and supplied to system support?		Completed ☐ N/A ☐	
5.13	Software and/or dataset Version or Release Description Documentation supplied and adequate?		Completed ☐ N/A ☐	**Link to Version Description Document or Release Description Document**
5.14	Software installation procedure and instructions supplied/updated and adequate?		Completed ☐ N/A ☐	**Link to Installation Procedure**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
5.15	**SMP**: System Management Plan created / updated and adequate?	SMP Template	Completed ☐ N/A ☐	**SMP No:**
5.16	**SCP:** System Contingency / continuity plans supplied/updated and adequate?	SCP Template	Completed ☐ N/A ☐	**SCP No:**
5.17	Technical drawings updated and listed in Data Viewer and list supplied to system supporters and field maintenance staff.	Technical Drawing Management PROC-178	Completed ☐ N/A ☐	
5.18	Technical handbooks/manuals supplied to ABS or FMS Engineering/IT support and field maintenance staff (base and site copy).	Document Management PROC-103	Completed ☐ N/A ☐	
5.19	On-line system support and field maintenance documentation completed and published		Completed ☐ N/A ☐	
5.20	Technical documentation registered and placed under documentation control	Document Management PROC-103	Completed ☐ N/A ☐	
5.21	Appropriate engineering performance requirements specified and issued for ongoing use? System Specification documentation supplied/updated and adequate?	System Performance Requirements & Reporting Specification ASYS-106	Completed ☐ N/A ☐	
5.22	**Configuration & Modification AEI:** Equipment and System Modifications and Configuration (for hardware and software), and Software Release Authorisations are documented in a Part 2 AEI (or other approved documentation)	Development of Maintenance Instructions for Equipment PROC-151	Completed ☐ N/A ☐	**AEI No/s:** **Link to documentation detailing configuration and modification**
5.23	**Maintenance AEI:** Maintenance requirements, including Performance Inspection tolerances, have been defined and documented in AEIs (or other approved documentation). (AEI Part 3,4,7)	Development of Maintenance Instructions for Equipment PROC-151	Completed ☐ N/A ☐	**AEI No/s:**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
5.24	**AEI:** New maintenance AEIs trialled by maintenance staff	Development of Maintenance Instructions for Equipment PROC-151	Completed ☐ N/A ☐	
5.25	**TTD**: Temporary Technical Dispensation raised and published on the Document Search database.	Temporary Technical Dispensations PROC-153	Completed ☐ N/A ☐	**TTD No:**
5.26	Site Manifest updated	Site Manifests FMS-304	Completed ☐ N/A ☐	
6	SYSTEM			
DESIGN REQUIREMENTS				
6.1	System Requirements documentation including Operating Concept or Business Process Rules - supplied/updated and approved?	Design Control PROC-146	Completed ☐ N/A ☐	**Links to documentation**
6.2	Standards – Installation and equipment comply with all relevant Australian Standards? Building Codes - Structures comply with the relevant Building Codes? The relevant Australian Standards and Building Codes are to be determined by the Chief Engineer, Technical Authority or Maintenance Authority	Australian Standards Design Control PROC-146	Completed ☐ N/A ☐	
6.3	Other applicable Federal and/or State licensing requirements met? The relevant licensing requirements are to be determined by the Chief Engineer, Technical Authority or Maintenance Authority	Design Control PROC-146	Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
6.4	Electrical Mechanical, Structure and Building impacts have been assessed as adequate or modifications organised and completed through consultation with Engineering Branch, P&E? (Power supply capability / airconditioning capacity / mast loadings)	Design Control PROC-146	Completed ☐ N/A ☐	
6.5	Earthing and Lightning Protection meets Airservices requirements?	Earthing and Lightning Protection Systems for Operational Facilities AEI 3.1504 Site Earthing and Lightning Protection Systems for Existing Installations AEI 2.3011	Completed ☐ N/A ☐	
6.6	Battery Procurement as per Airservices requirements?	Lead Acid Batteries (Stationary) Procurement and Acceptance Testing AEI-3.7050 Panel Contract Arrangement C-PROC0140	Completed ☐ N/A ☐	
6.7	Assessing the impact of information systems against corporate objectives (7 Ticks process).	Information Technology Application Certification –'7 Ticks' MI-0804 and PROC-190	Completed ☐ N/A ☐	**Link to completed 7 Ticks Interim Certificate or Final Certificate**
6.8	IT Security measures appropriate and in place(ie. to ensure effective security and control practices to minimise the risks of unauthorised access, inappropriate use, modification, destruction or disclosure of electronically held data).	IT Security Roles and Responsibilities Statement MS-0013 Information Security MI-0808 ICT Resources – Conditions of Use MI-0829	Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
6.9	Information Security	Information Security C-PROC0184	Completed ☐ N/A ☐	**Link to completed security risk management plan**
INSTALLATION REQUIREMENTS				
6.10	Has met the regulation and safety requirements for Telecommunications Installations. Cable Markers installed (external)? Equipment complies with ACMA statutory requirement Telecommunication Labelling (Customer Equipment and Customer Cabling) Notice 2001 as amended (i.e. 'A' ticked on the equipment compliance plate)	Implementing Regulation and Safety Requirements for Telecommunications Installations PROC-138 Installation of Optical Fibre Cable - Underground AEI 4.5001 Underground Cable Marking AEI 4.3001	Completed ☐ N/A ☐	**Link to Telecommunications Cabling Advice**
6.11	MDF/IDF Records created / updated? Labelling/Colour Coding – Rack, Cable, Chassis, etc.?	Colour Coding of RJ45 Patch Leads for Voice and Data Installations AEI 7.3241	Completed ☐ N/A ☐	
6.12	Transmitters licence label affixed	Radio Communication Transmitter Labelling AEI 7.4238	Completed ☐ N/A ☐	
6.13	Electrical Certificate of Testing and Safety or Testing and Compliance on connection to a source of electricity (i.e. installation conforms to AS3000) are required to be supplied as soon as possible after connection or testing of any electrical installation or change. Labelling – Switch Boards, etc Meets Airservices Electrical Cable Colour Coding requirements?	Electrical Safety Regulation 2002 Sections 15 and 159 AS 3000 – Aust Standard Electrical Cable Colour Coding AEI 3.1502	Completed ☐ N/A ☐	**Links to Electrical Certificates**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
6.14	All modifications complete and scratch plate labels affixed to equipments	Identification of Airways Systems Equipment Hardware Modifications PROC-154	Completed ☐ N/A ☐	
6.15	Integration with National Technical Monitoring has been organised and completed through Engineering Branch, P&E?		Completed ☐ N/A ☐	
6.16	Alarm monitoring installed and tested at TOC for local and remote site?		Completed ☐ N/A ☐	
6.17	Source media – supplied/backed up, stored, registered with system support?	Software Media Archival and Storage PROC-147	Completed ☐ N/A ☐	
6.18	Site installable media – supplied/backed up, appropriately stored and registered by field maintainers?	Software Media Archival and Storage PROC-147	Completed ☐ N/A ☐	
6.19	Software licences provided, registered and appropriately stored? (Including details of any third party licensing)		Completed ☐ N/A ☐	
6.20	Update HEAT and/or ASID database to incorporate new system/version number and assign issue management roles?		Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
DESIGN CONFIRMATION				
6.21	Airservices Physical Security requirements met. The minimum security requirements are specified in C-GUIDE0157. Physical Security advise can be obtained from the relevant Security Advisor in Security and Crisis Planning, Safety & Environment Physical Access requirements are determined and established Siting and accommodation impact has been assessed as being satisfactory or modifications organised through National Property?	Physical Security – Critical Operational Facilities C-GUIDE0157 Site Management PROC-170	Completed ☐ N/A ☐	
6.22	Network data load impact has been assessed as being satisfactory or modifications organised and completed through Engineering Branch, P&E?		Completed ☐ N/A ☐	
6.23	Spectrum licences (either cancelled if no longer required or for new licenses including if antenna moves by more than 10 metres)	Frequency Management: Obtaining a Frequency Assignment and Licence AEI 7.4202	Completed ☐ N/A ☐	
6.24	New system or system change acceptance tests (software and/or hardware) satisfactorily completed against the approved system requirements? – Test Plans provided? – FAT, SAT, UAT test results complete, passed to the required level and provided? – Test identified defect listings and re-test information provided?	System Management Manual SMM Design Control PROC-146	Completed ☐ N/A ☐	
6.25	Battery Acceptance Tests as per Airservices requirements?	Lead Acid Batteries (Stationary) Procurement and Acceptance Testing AEI-3.7050	Completed ☐ N/A ☐	**Link to Battery Acceptance Test Results**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
6.26	Standard Operating Conditions (SOCs) / Site Configuration Data (SCD) established / approved	Standard Operating Conditions & Site Configuration Data Management PROC-143	Completed ☐ N/A ☐	
6.27	Flight Test results supplied and satisfactory	Certification of Radio Navigation Aid Facilities AEI 7.4003	Completed ☐ N/A ☐	
6.28	Equipment operation is as per AEI specifications and any additionally specified requirements? Relevant requirements and performance specifications to be determined by the Chief Engineer, Technical Authority or Maintenance Authority		Completed ☐ N/A ☐	
7	**TRANSITION**			
PLANNING				
7.1	Does the system meet all critical user and technical requirements?		Completed ☐ N/A ☐	
7.2	If non-critical deficiencies are proposed to be accepted into operation, are they managed and tracked via ASID, HEAT or SAIR, including responsibilities and timings and attached to the Commissioning Certificate?		Completed ☐ N/A ☐	
7.3	Cutover Plan prepared and authorised by: – Appropriate level of engineering authority? – Appropriate level of User Authority?	Cutover Plan C-TEMP0045	Completed ☐ N/A ☐	**Link to Cutover Plan**
7.4	Works plan created at least 7 days before deployment	Works Planning PROC-213	Completed ☐ N/A ☐	**Works Plan No.**

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
NOTIFICATION				
7.5	Industry education / notification been completed?		Completed ☐ N/A ☐	
7.6	Relevant Business Managers advised of impending change?		Completed ☐ N/A ☐	
7.7	Change requester and/or sponsor notified?		Completed ☐ N/A ☐	
7.8	System Operations' TOC and Service Desk notified and accepted operating responsibility for the change.		Completed ☐ N/A ☐	
7.9	ABS/FMS Manager has accepted maintenance responsibility		Completed ☐ N/A ☐	
7.10	Notify the following (as appropriate) that the system is at **"OPERATIONAL READINESS"** and provide details of commissioning and any system changes: **ATC** System Supervisor, Melbourne (ATC) System Supervisor, Brisbane (ATC) National ATC Systems Manager Operating Authority (relevant)	**Sys to Svc List**	Completed ☐ N/A ☐	

Item No:	Requirement:	Requirement Reference: (Procedure/instruction used to specified required input)	Completed or N/A	Evidence of Compliance (If a requirement is N/A, a reason why it is N/A is required to be entered)
7.11	Notify the following (as appropriate) that the system is at **"ENGINEERING READINESS"** and provide details of commissioning and any system changes: **P&E** Technical Authority (relevant) Technical Operations Centre – Director Service Desk -Airways SAP PM Support	Sys to Svc List	Completed ☐ N/A ☐	

airservices

Appendix B

SYSTEM MANAGEMENT MANUAL
CHANGE CONTROL
C-FORMS0300

COMMISSIONING CERTIFICATE		
The requirement for this form is specified in the System Management Manual (Section 11.2 of V4), C-MAN0107		
Project/Task Name	**SAP Project/Task ID:**	**Sites or Locations affected:**
Documentation prepared by:	**Date:**	**Commissioning Date:**
Affected System(s)	**System Criticality**	**Change Consequence Level**
Brief Description of Change:		

Commissioning Approval		
The approval of this document by the appropriate authorities as specified in the System Management Manual certifies that the new system or system change is satisfactory to meet the specified service and performance requirements; that system operating and support requirements are in place; that required user and technical training is adequately provisioned; as detailed in the Commissioning Readiness Form and consequently the new system or system change is declared fit-for-purpose and can be deployed and operated until formally decommissioned or otherwise revoked. This approval is provided subject to the non-critical deficiencies[1] listed herein.		
Chief Engineer, Technical or Maintenance Authority		
Name	**Signature:**	**Date**
Designation:		
Name:	**Signature:**	**Date:**
Designation:		
Chief Operating/User Authority or Operating/User Authority		
Name:	**Signature:**	**Date:**
Designation:		

Records Management Instructions
Place the completed Commissioning Certificate, together with the completed Commissioning Readiness form on the Project file
Provide a copy of the completed Commissioning Certificate, and the completed Commissioning Readiness Form to P&E, Asset Lifecycle Manager, Planning and Integration

Note 1: **Non-critical deficiencies** are those outstanding technical and operational issues that do not prevent the safe and effective use of the facility by users or prevent effective technical maintenance, but will be addressed in a specified and agreed time.

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Form approved by: Branch Manager, Operational Integrity & Compliance

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SYSTEM MANAGEMENT MANUAL
CHANGE CONTROL
C-FORMS0300

LIST OF NON-CRITICAL DEFICIENCIES WAIVED AT TIME OF COMMISSIONING

Either list non-critical deficiencies here or attach a list if space insufficient

Issue	Issue Tracking Reference Number	Allocated to	Proposed Completion Date	Comments

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Appendix 2

Guidance Materials on Monitoring and Analysis of ADS-B Avionics Performance

1 Introduction

1.1 The APANPIRG has endorsed the following Conclusion during its 24th Meeting to encourage States/Administration to exchange their ADS-B performance monitoring results and experience gained from the process :

Conclusion 24/45 - Exchange ADS-B Performance Monitoring Result
"That, States be encouraged to exchange findings/result of their ADS-B performance monitoring including experience gained in conducting the required performance monitoring."

1.2 Since the ADS-B mandate for some airspace in the Region became effective in December 2013, monitoring and analysis on avionics performance of ADS-B equipped aircraft has become an increasingly important task for concerned States. The fully functional ADS-B Avionics Problem Reporting Database (APRD) was launched on the 21 July 2017. The database is placed at ICAO APAC website in the restricted area with name: APAC ADS-B Avionics Problem Reporting Database accessible via https://applications.icao.int/ADSB-APRD/login.aspx. States are encouraged to make full use of the APRD for reporting ADS-B avionics problems and sharing experience as well as follow-up actions through the APRD web-page.

1.3 This document serves to provide guidance materials on monitoring and analysis of avionics performance of ADS-B equipped aircraft, which is based on the experience gained by States.

2 Problem Reporting and Feedback

2.1 For ADS-B avionics problems, it is critical that an appropriate reporting and feedback mechanism be established. It is highly desirable that those discovering the problems should report them to the appropriate parties to take action, such as study and analyse the problems, identify the root causes, and rectify them. Those action parties include :-

(a) Air Navigation Service Providers (ANSPs) – upon detection of any unacceptable ADS-B reports from an aircraft, report the observed problem to the performance monitoring agent(s), if any, and the Aircraft Operators for investigation. In addition, ANSPs should take all actions to avoid using the ADS-B reports from the aircraft until the problem is rectified (e.g. black listing the aircraft), if usage of such reports could compromise safety.

(b) Regulators – to initiate any appropriate regulatory action or enforcement.

(c) Aircraft Operators – to allow avionics specialists to examine the causes and as customers of the avionics manufacturers ensure that corrective action will take place.
(d) Avionics Manufacturers and Aircraft Manufacturers – to provide technical evidence and knowledge about the problem and problem rectification

2.2 Incentives should be received by those parties acting on the problems including :-

(a) Regulations that require deficiencies to be rectified
(b) Regulatory enforcement
(c) Consequences if conduct of operations with problematic equipment (e.g. no access to the airspace requiring healthy equipment)

2.3 When an ADS-B avionics problem is reported, it should come along with adequate details about the problem nature to the action parties. In addition, the problem should be properly categorised, so that appropriate parties could diagnose and rectify them systematically.

3 Problem Categorisation

3.1 Regarding ADS-B avionics, their problems are quite diversified in the Region but can be categorized to ensure they will be examined and tackled systematically.

3.2 Based on the experience gained from States, the common ADS-B avionics problems in the Region are summarized under different categories in Attachment A. It is noted that only a relatively minor portion of the aircraft population exhibits these problems. It must be emphasized that aircraft transmitting incorrect positional data with NUC = 0 or NIC = 0 should not be considered a safety problem. The data transmitted have no integrity and shall not be used by ATC. This situation exists for many aircraft when their GNSS receivers are not connected to the transponders.

4 Managing the Problem

4.1 There are two major approaches to manage the problems :-

(a) Regulatory approach
Regulations which require non-approved avionics to disable ADS-B transmission (or transmit "no integrity"), and the concerned operators to file flight plans to indicate no ADS-B equipage. APANPIRG has endorsed this approach which is reflected in the Regional Supplementary Procedures (Doc 7030).

(b) Blacklist approach
Filtering out ("black listing") any airframes that do not comply with the regulations or transmitting bad data, and advising the regulator of the non-

compliance. This approach is temporary which allows the ANSP to protect the system whilst regulatory action is underway.

While deciding on whether an aircraft transmitting erroneous ADS-B data should be added into the blacklist, the following factors will be critically assessed:

i. Impact and risk to ATC operational safety

Use of erroneous ADS-B data to maintain separation may potentially contribute to loss of separation or ATC coordination error.

ii. Frequency of erroneous position

Whether it is occasional or frequently broadcast of erroneous position.

iii. Amount of deviation

This can be a track jumping problem which is of significant safety impact to ATC or just an occasional small position jump which is not detectable in ATC with insignificant impact.

iv. Others

Such as the ICAO aircraft address received from ADS-B being inconsistent with the aircraft registration, Flight ID entered via cockpit interface mismatched with aircraft callsign in the Flight Plan, etc.

After deciding to put an aircraft into the blacklist list, the following procedures will be carried out:

i. Informing the concerned aircraft operator/regulatory authority

The concerned aircraft operator/regularity authority will be notified of the decision and the rationale before putting the aircraft into the exclusion list.

ii. Pre-processing of flight plan concerned

As the blacklist mechanism involves filtering out the ADS-B data of the subject aircraft, from operational perspective, air traffic controllers need to be aware in advance that the concerned aircraft plans to operate in their FIR. A flight plan pre-processing system may locate the flight plan by checking against the 24-bit address or aircraft registration in the blacklist, and issue an alert to the air traffic controllers if appropriate, such as automatically insert a remark in the Item 18 of the concerned flight plan before feeding the flight plan into the ATC Automation System, and the ATC Automation System may issue an alert to the air traffic controllers with a specific label annotated in the corresponding electronic flight strips.

iii. Coordinate with adjacent Area Control Centre (ACC)

Upon posting of pending inbound flights with corresponding electronic flight strips indicating non-ADS-B equipage or in the blacklist, the air traffic controllers shall inform the upstream ACC that transfer of that particular flight will not be accepted at the ADS-B exclusive airspace. It is important to carry out this coordination action as early as possible as the upstream sector may have difficulty to adjust the flight route at the transfer stage.

iv. Handling of an aircraft for removal from the blacklist once rectification action had taken place

Once notification from the aircraft operators/regulatory authorities is received that the problem has been rectified, performance of the aircraft will be closely monitored when it flies to the concerned FIR. If the aircraft shows the observed problem has been resolved, the aircraft will be removed from the blacklist. The aircraft operator/regulatory authority will also be notified accordingly.

5 Systematic Monitoring and Analysis of the Problem

States using ADS-B should have in place systematic ways to identify and manage ADS-B deficiencies similar to that described below :-

5.1 Reporting Deficiencies

States using ADS-B should have in place systematic ways to identify ADS-B deficiencies including :-

(a) Systematic capture of ATC reported events and engineering detected events into a database; and

(b) Manual or automatic detection of anomalous avionics behavior independent from controller reports

5.1.1 ATC Reported Deficiencies

ATC procedures should exist that allow services to continue to be provided 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) NUCp of each ADS-B reported position is smaller than required for service delivery for more than 5% of total number of ADS-B updates;

(b) NIC, NACp, SIL are smaller than required for service delivery for more than 5% of total number of ADS-B updates;

(c) ICAO Aircraft Address (i.e. I021/080) is inconsistent with the flight planned registration (REG) based on each state's ICAO Aircraft Address allocation methodology;
(d) Flight ID entered via cockpit interface and downlinked in ADS-B data (i.e. I021/170 in Asterix CAT 21) is a 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.

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

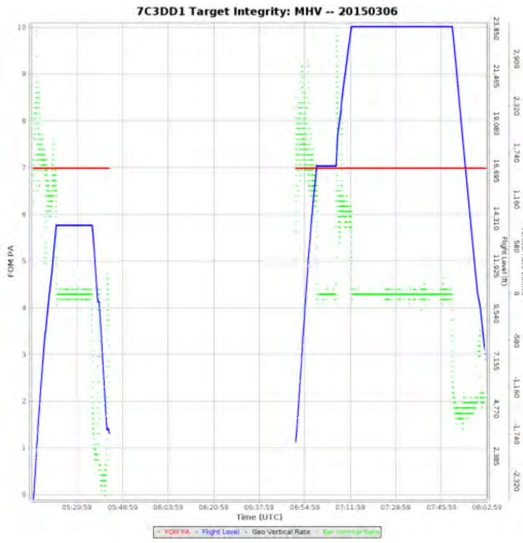
Whether detected by ATC or not, all deficiencies should trigger:

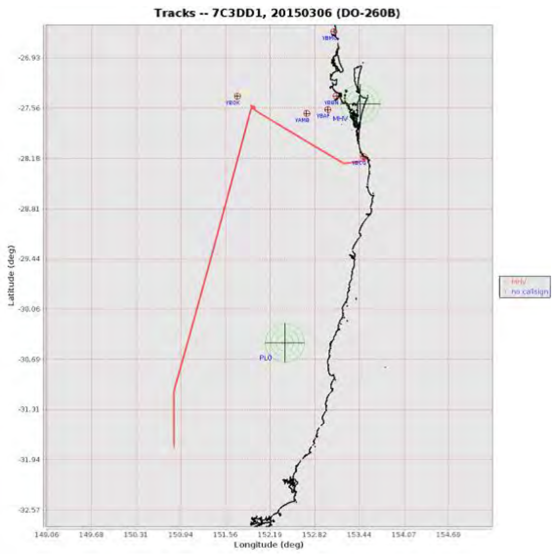
(a) Systematic recording of the details of each occurrence such as date/time of occurrence, ICAO aircraft address and flight plan information should be obtained. Graphical representations such as screen capture of radar and ADS-B history

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

[2] For example, the deviation between ADS-B and radar tracks could be set to 1NM in accordance with ICAO Circular 326 defining position integrity (0.5NM < 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 (NUCp, NACp, SIL, NIC) could be chosen based on the definition in ICAO Circular 326 on Position Accuracy and Position Integrity for 3NM aircraft separation minimum. A threshold of 5% is initially set to exclude aircraft only exhibiting occasional problems during their flight journey. The above criteria should be made configurable to allow fine-turning in future. Evaluation of ADS-B vs radar may alternatively expose radar calibration issues requiring further investigation.

tracks, graphs of NUCp/NIC value changes versus time and deviation between radar and ADS-B tracks along the flight journey would be desirable. Examples of typical graphical representations are shown below :-





(b) Systematic technical analysis of each detected issue using ADS-B recorded data, to ensure that all detected issues are examined and addressed. Typically this will need:

- systems to record ADS-B data, replay ADS-B data and analyze ADS-B data
- staff and procedures to analyze each report
- A database system to manage the status of each event and to store the results of each analysis

(c) Procedures to support engagement with operators (domestic & foreign), regulators, other ANSPs, Airframe OEMs and avionics vendors to ensure that each issue is investigated adequately and maximize the probability that the root cause of the event is determined. The procedures could include :-

- Data collection procedures;
- Telephone & email contact details; and
- Mechanisms for reporting, as appropriate, to the Asia Pacific ADS-B Avionics Problem Reporting Database (APRD)

* * * * * * * *

Attachment A – List of known ADS-B avionics problems

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
1.	Track Jumping problem with Rockwell Collins TPR901 (See Figure1)	Software issue with TPR901 transponder initially only affecting Boeing aircraft. Does not occur in all aircraft with this transponder. Subsequent investigation by Rockwell Collins has found that the particular transponder, common to all of the aircraft where the position jumps had been observed, had an issue when crossing ±180 degrees longitude. On some crossings (10% probability), errors are introduced into the position longitude before encoding. These errors are not self-correcting and can only be removed by a power reset of the transponder. The problem, once triggered can last days, since many transponders are not routinely powered down.	**Yes.** Will present as a few wild/large positional jumps. Nearly all reports are tagged as low quality (NUC=0) and are discarded, however, some occasional non zero reports get through. Problem is very “obvious”. Could result in incorrect longitudinal position of Flight Data Record track. Can trigger RAM alerts.	Rockwell Collins has successfully introduced a Service Bulletin that solves the problem in Boeing aircraft. The problem is known to exist on Airbus aircraft. Rockwell has advised that a solution is available in their DO260B upgrade. Rockwell Collins may not have a fix for some time. Workaround solutions are being examined by Airbus, Operators and Airservices Australia. The only workaround identified at this time is to power down the transponders before flight to states using ADS-B – after crossing longitude 180. It can be noted that in Airbus aircraft it is not possible to safely power down the transponder in flight. Airbus have prepared a procedure to support power down before flight. Airservices Australia have negotiated with 2 airlines to enact this procedure prior to flights to Australia. An additional partial workaround is :

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				to ensure that procedures exist for ATC to ask the pilot to changeover transponders if the problem is observed. Since there is a 10% chance of the problem occurring on each crossing of ±180 degrees longitude, the chance that both transponders being affected is 1%. There is no complete workaround available for flights that operate across 180 degrees longitude directly to destination without replacing the transponder. Airbus advised that a new TPR901 transponder compliant with DO260B is available from December 2015. This new transponder does not have such problem.
2.	Rockwell Collins TDR94 Old version. The pattern of erroneous positional data is very distinctive of the problem. (See Figure 2)	Old software typically before version -108. The design was completed before the ADS-B standards were established and the message definitions are different to the current DO260. Rockwell has recommended that ADS-B be disabled on these models.	**Yes.** Will present as a few wild positional jumps. Nearly all reports are tagged as low quality (NUC=0) and are discarded, however, some occasional non zero reports get through. Also causes incorrect altitude reports. Problem is very "obvious".	Problem well known. Particularly affects Gulfstream aircraft which unfortunately leave the factory with ADS-B enabled from this transponder model. Rockwell has issued a service bulletin recommending that ADS-B be disabled for aircraft with this transponder software. See Service Information Letter 1-05 July 19, 2005. It is easy to disable the transmission.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
3.	Litton GPS with proper RAIM processing	Litton GNSSU (GPS) Mark 1 design problem. (Does not apply to Litton Mark II). GPS does not output correct messages to transponder.	**No.** Perceived GPS integrity changes seemingly randomly. With the GPS satellite constellation working properly, the position data is good. However the reported integrity is inconsistent and hence the data is sometimes/often discarded by the ATC system. The effected is perceived extremely poor "coverage". The data is not properly "protected" against erroneous satellite ranging signals – although this cannot be "seen" by ATC unless there is a rare satellite problem.	This GPS is installed in some older, typically Airbus, fleets. Data appears "Correct" but integrity value can vary. Performance under "bad" satellite conditions is a problem. Correction involves replacing the GNSSU (GPS) which is expensive. If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
4.	SIL programming error for DO260A avionics	Installers of ADS-B avionics using the newer DO260A standard mis program "SIL". a) This problem appears for DO260A transponders, with SIL incorrectly set to 0 or 1 (instead of 2 or 3) b) As the aircraft enters	**No.** First report of detection appears good (and is good), all subsequent reports not displayed because the data quality is perceived as "bad" by the ATC system. Operational effect is effectively no ADS-B data. Hence no risk.	Would NOT be included in a "black list". Aircraft with "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
		coverage, the ADS-B ground station correctly assumes DO260 until it receives the version number. c) The transmitted NIC (DO260A) is interpreted as a good NUC (DO260) value, because no SIL message has yet been received. The data is presented to ATC.		
5.	Garmin "N" Flight ID problem (See Figure 3)	Installers of Garmin transponder incorrectly set "Callsign"/Flight ID. This is caused by poor human factors and design that assumes that GA aircraft are US registered.	**Yes.** Flight ID appears as "N". Inhibits proper coupling.	Can be corrected by installer manipulation of front panel. Does not warrant "black list" activity.
6.	Flight ID corruption issue 1 – trailing "U" Flight ID's received : GT615, T615U ,NEB033, NEB033U, QF7550, QF7550U, QF7583, QF7583U, QF7585, QF7585, QF7585U, QF7594, QFA7521, QFA7531, QFA7531, QFA7531U, QFA7532, QFA7532U, QFA7532W, QFA7550, QFA7552,	TPR901 software problem interfacing with Flight ID source. Results in constantly changing Flight ID with some reports having an extra "U" character.	**Yes.** Flight ID changes during flight inhibits proper coupling or causes decoupling.	Affects mainly B747 aircraft. Boeing SB is available for Rockwell transponders and B744 aircraft. Rockwell Collins have SB 503 which upgrades faulty -003 transponder to -005 standard. If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	QFA7581			
7.	Flight ID corruption issue 2	ACSS software problem results in constantly changing Flight ID. Applies to ACSS XS950 transponder Pn 7517800-110006 and Honeywell FMC (pn 4052508 952). ACSS fix was available in Sept 2007.	**Yes.** Flight ID changes during flight inhibits proper coupling or causes decoupling.	Software upgrade available. If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
8.	No Flight ID transmitted	Various causes	**No.** Flight ID not available. Inhibits proper coupling.	Aircraft could "fail to couple with Flight Data Record". Not strictly misleading – but could cause controller distraction.
9.	ACSS Transponder 10005/6 without Mod A reports NUC based on HFOM.		**Yes.** Appears good in all respects until there is a satellite constellation problem (not normally detectable by ground systems).	Not approved and hence not compliant with CASA regulations. If known could be added to black list. Configuration is not permitted by regulation.
10.	Occasional small position jump backwards (See Figure 4)	For some older Airbus aircraft, an occasional report may exhibit a small "jump back" of less than 0.1 nm Root cause not known	**No.** Not detectable in ATC due to extrapolation, use of latest data and screen ranges used.	ATC ground system processing can eliminate these.
11.	Older ACSS transponders report integrity too conservatively	Design error reports integrity one value worse than reality	**No.** In poor GPS geometry cases the	Can be treated in the same manner as a loss of transponder capability.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
			ATC system could discard the data when the data is in fact useable. Will be perceived as loss of ADS-B data.	
12.	Intermittent wiring GPS transponder	ADS-B transmissions switch intermittently between INS position and GPS position.	**Yes.** Normally the integrity data goes to zero when INS is broadcast, but sometimes during transition between INS and GPS, an INS position or two can be broadcast with "good" NUC value. Disturbing small positional jump.	If a new case is discovered, an entry needs to be made to the black list until rectification has been effected.
13.	Wrong ICAO Aircraft Address	Installation error	**No.** No direct ATC impact unless a rare duplicate is detected.	This is not a direct ADS-B problem, but relates to a Mode S transponder issue that can put TCAS at risk. Cannot be fixed by black list entry. Needs to be passed to regulator for resolution.
14.	Toggling between high and low NUC (See Figure 5)	Faulty GPS receiver/ADS-B transponder	**No.** ATC will see tracks appear and disappear discretely. No safety implications to ATC.	While it is normal for NUC value to switch between a high and low figure based on the geometry of GPS satellites available, it is of the view that more should be done to examine this phenomenon. It is observed that such switching between high and low NUC occurs on certain airframe and

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				not on others. The issue was raised to the airlines so as to get a better understanding. On one occasion, the airline replied that a module on their GPS receiver was faulty. On another occasion, the airline replied that one of the ADS-B transponder was faulty. Good NUC was transmitted when the working transponder was in use and poor NUC was transmitted when the faulty ADS-B transponder was in use.
15.	Consistent Low NUC (See Figure 6)	GNSS receivers are not connected to the ADS-B transponders.	**No.** Data shall be filtered out by the system and not detectable in ATC	Not considered a safety problem but a common phenomenon in the Region – the concerned aircraft will be treated equivalent to "aircraft not equipped with ADS-B". While it is normal for aircraft to transmit low NUC, it is of the view that "consistent low NUC' could be due to the avionics problem (e.g. GNSS receiver is not connected to the ADS-B transponder). It is recognised that operators may not be aware that their aircraft are transmitting unexpected low NUC / NIC values, due to equipment malfunction. Hence, it is desirable for States to inform the operators

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 NIC	Issue 1: 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. Issue 2: Data packets were not being distributed to the transponder when the internal timing between different elements of the Integrated Surveillance System became synchronized.	**Yes.** Misleading position presentation which is typically detected by ATC observing aircraft "off track" when in fact it is "on-track".	Boeing performed a change to the B787 Type Certificate for incorporation of the upgraded ISS software in March of 2017. All B787 aircraft delivered after Line number 541 have the upgraded ISS software which corrects this issue. Boeing released Service Bulletin B787-81205-SB340036-00 on 30 June 2017. Note that this Service Bulletin is available at no cost to the operator, and includes the concurrent requirement to implement Boeing Service Bulletin B787-81205-SB340005-00. On 5 Nov 2018, FAA issued Airworthiness Directive 2017-NM-118-AD, effective 10 Dec 2018, which requires application of Boeing SB B787-81205-SB340036-00 by 10 Dec 2019. EASA has invoked this AD for States under its jurisdiction. States and Operators are urged to implement the service bulletin immediately and report to FAA or ICAO APAC Office. As of 9 Sep 2020, 32 B787 aircraft were on the NSAL; 18 of these

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
				aircraft have been detected within U.S. ADS-B coverage during 2020. The FAA is coordinating with State Regulators who have operators with B787 aircraft on the NSAL.
19	A number of airlines have reported or experienced ADS-B outages for complete flight sectors in A330 aircraft. Appears as low reliability ADS-B and has afflicted both A & B side at same time.	Being actively investigated. One airline has implemented on-board recording which confirms that the MMRs are not providing HIL/HPL to the transponder whilst continuing to provide HFOM, GPS alt etc	**No.** Equivalent to a failed transponder.	Aircraft must be managed procedurally if outside radar coverage.
20	A380 flight ID lost after landing	For the A380 fleet, it has been confirmed that for some seconds after landing, the flight ID is set as invalid by FMS to 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.
21	A350 ADS-B On-ground Performance	On departure, A350 aircraft will initially use INS derived position for ADS-B reports when taxying and only use GNSS when entering the runway. INS positions can	**Yes. where ADS-B is used for surface movement display**	Airbus is in discussion with FAA and EUROCONTROL about this issue.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		drift leading to inaccurate position reports.		
22	Incorrect Ground Bit Setting (GBS) in both Mode S Interrogation Reply and ADS-B Downlink	Occasionally, some airborne aircraft will incorrectly set ground bit as "1" meaning they are on ground, while some landed aircraft incorrectly set ground bit as "0" meaning they are airborne. This could confuse the ATC system, by not showing the airborne targets as the system thought they are on ground, or forming tracks for landed targets triggering alarms against other taking-off aircraft.	**Yes. Misleading information shown on ATC system. Aircraft not visible to TCAS and will not reply to all-call interrogations.**	States/Administrations contact the concerned airline operators for remedial actions.
23	Rockwell TSS-4100 track extrapolation issue.	The TSS-4100 shares software with the Rockwell Collins ISS transponder in the B787, and the software defect in the B787 ISS reported at SURICG/2 also exists in the TSS-4100.	**Yes. Misleading position presentation which is typically shown on ATC system.**	FAA Airworthiness Directive (AD) 2017-22-14 was issued on 20 Dec 2017. The compliance date for this AD is 20 Dec 2018 (or 750 hours in service, whichever occurs first). FAA has not detected any aircraft with this issue since the AD compliance date and will not further report on it, as it is considered resolved.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
24	Embraer 170 track jumping issue	Unknown as being a random, occasional issue with no clear fault diagnosis available from Honeywell. FAA has decided that when the next E170 aircraft is detected with this issue, it will be immediately placed on the FAA's No Services Aircraft List (NSAL). Simultaneously, FAA will notify Embraer and Honeywell of the affected aircraft and request that appropriate engineering personnel be sent to inspect and test the affected aircraft.	**Yes. Misleading position presentation which is typically shown on ATC system.**	In all of the cases of this issue to date, removing and replacing the transponders cleared whatever the issue was. This issue has never recurred on the same aircraft. Bench testing by Honeywell avionics engineering of the removed transponders has revealed no faults or anomalies. As such, States/Administrations to consider removing and replacing the transponders concerned if issue observed. The FAA has since learned from discussions with the OEM that most recent events detected by FAA generated an "ADS-B NOT AVAIL" Crew Alerting System (CAS) message. When flight crews report this message, airline maintenance replaces the transponder(s), which resolves the problem. To date, this has consistently occurred before FAA monitoring detected the problem and engaged with the airline. The root cause for this issue remains unknown.
25	Airbus Single Aisle production wiring issue	FAA has observed 17 Airbus Single Aisle aircraft from two airlines with missing	**No.**	Airbus released three Service Bulletins to correct this issue, which existed in 128 Airbus Single Aisle

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		Length-Width Codes (LWC is a message element in DO-260B/ED-102A that is required by both the US and European mandates). FAA believes that this was a production line wiring issue.		aircraft. As of 1-Dec-2018, all of the aircraft which operate at US airports with ADS-B surface surveillance were corrected. The FAA will not further report on this issue.
26	Boeing 777-300ER production wiring issue	FAA has observed at least 10 Boeing B777-300ER aircraft with missing or improper NACv/SDA/eCat/LWC message elements (these are message elements in DO-260B/ED-102A that are required by both the US and European mandates (eCat is FAA shorthand for Emitter Category). After notification, Boeing reported to FAA that this was a production line parity pin wiring issue.	**No.**	On 7 July 2017, Boeing released Service Bulletin SB 777-34-0281 to correct this issue. Boeing has informed FAA that all affected B777 operators have been notified. The FAA will not further report on this issue.
27	Rockwell TSS-4100 Geometric Altitude Reporting as Pressure Altitude	This issue exists in any TSS-4100 installed with TSSA-4100 software RCPN 810-0052-100, RCPN 810-0052-101, or RCPN 810-0052-102. All of the following must be true for the issue to occur: (1) TSS is the selected transponder;	**Yes.**	At present, the FAA regulator has determined that this issue occurs too rarely to warrant issuing an Airworthiness Directive or a Special Airworthiness Information Bulletin (SAIB). Rockwell Collins has released updated software, RCPN 810-0052-110, to address this issue. Refer to

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		(2) TSS is receiving valid pressure altitude; (3) TSS is receiving valid GPS data with an integrity of NIC 9 or better; and (4) The mode of operation for the transponder must be "ALT OFF". Note that in an SBAS service area, only condition (4) would be considered uncommon. When the issue exists, the TSS will insert geometric altitude information into the ADS-B Airborne Position Squitter, but this altitude will be encoded as if it were pressure altitude. The net effect is that, when this issue occurs, the TSS-4100 reports geometric altitude information as if it were pressure altitude. In many cases, this will be incorrect altitude information.		SIL TSSA-4100-10-1 titled, "TSSA-4100 Field Loadable Software", RCPN 523-0818785.
28	NACv reporting greater	The FAA has detected a	**No.**	While there is no known urgent issue

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
	than 2	number of aircraft which consistently report NACv = 3 and NACv = 4. Per FAA AC 20-165B section 3.3.3.7.3, "A NACv = 3 or NACv = 4 should not be set based on GNSS velocity accuracy unless you can demonstrate to the FAA that the velocity accuracy actually meets the requirement." EASA CS-ACNS states that "There is currently no established guidance on establishing a NACv performance of 'three' or better." Therefore, it appears that there are improperly configured ADS-B installations operating in the U.S.		with these findings, as no known ATC or airborne application requires NACv values exceeding two, FAA does have long-term intentions of deploying surveillance tracking and alerting prediction algorithms in ATC automation which will use real-time NACv values. ICAO States planning to make similar improvements should be aware of this situation.
29	B787 NACv = 0 Issue	FAA noted certain B787s exhibiting a relatively high percentage of NACv =0 reports. Starting with line number 442 (June 2016), Honeywell Integrated Navigation Receiver (INR) P/N 940-	**No.**	The erroneous NACv=0 condition clears at the next power up of the ISSPU. Boeing has issued guidance urging B787 operators to not intermix INR P/N 940-2001-002 or -004 (which do not output HFOMv) with INR P/N 940-2001-008 (which does output

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		2001-008 was introduced, which has an HFOMv output. Boeing investigations revealed a software flaw in the ISSPU that causes an erroneous NACv=0 reporting condition on B787s equipped with a mixed set of Honeywell INR part numbers. This condition occurs when the ISSPU switches between an INR with an HFOMv output and an INR without an HFOMv output.		HFOMv) until the ISSPU software has been updated per an available Boeing Service Bulletin. This guidance was provided in Boeing Fleet Team Digest 787-FTD-34-19005 (dated 21 Dec 2019). As of 9-Aug-2020, FAA has observed no significant occurrences of this issue within U.S. ADS-B coverage during the prior two months.
30*[MC2]*	Honeywell Primus II RCZ issue	FAA observed that a number of operators equipped with the Honeywell Primus II integrated system were filing flight plans as ADS-B equipped, but not transmitting ADS-B. Honeywell had identified an issue where the ADS-B Out capable RCZ transponder and Radio Management Unit (RMU) components of the Primus II system will not broadcast ADS-B data if powered on under specific conditions. Also, the Radio	**No**	In October 2015, Honeywell released a Service Information Letter (Publication Number D201507000061) to notify customers of these power up conditions, the effect it would have on the Primus II equipment, and a potential work around to address the problem. In December 2019, Honeywell released Service Bulletin (SB) (Publication Number A21-2254-148) providing required modifications for the RMU to correct the ON/OFF logic for the ADS-B Out functionality.

Ref.	Problem	Cause	Safety Implications to ATC (Yes / No)	Recommendations
		Management Unit (RMU) will fail to notify the flight crew that ADS-B Out functionality is disabled.		The FAA has been working in collaboration with Honeywell to update the existing Service Information Letter to emphasize the importance of updating the RMU with the latest SB, to include implementing the option of configuring the ADS-B Out installation through a strap setting to provide indication of the ON/OFF control of ADS-B to the flight crew. The latest revision of the Service Information Letter will be referenced as part of the FAA issued Special Airworthiness Information Bulletin (SAIB) expected to be released before the end of December 2021.

Figure 1 - Track Jumping problem with TPR901

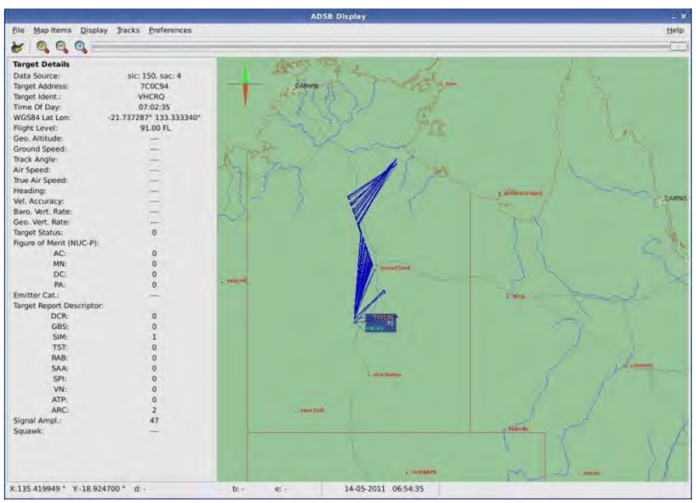


Figure 2 - Rockwell Collins TDR94 Old version. The pattern of

Figure 3 - Garmin "N" Flight ID problem

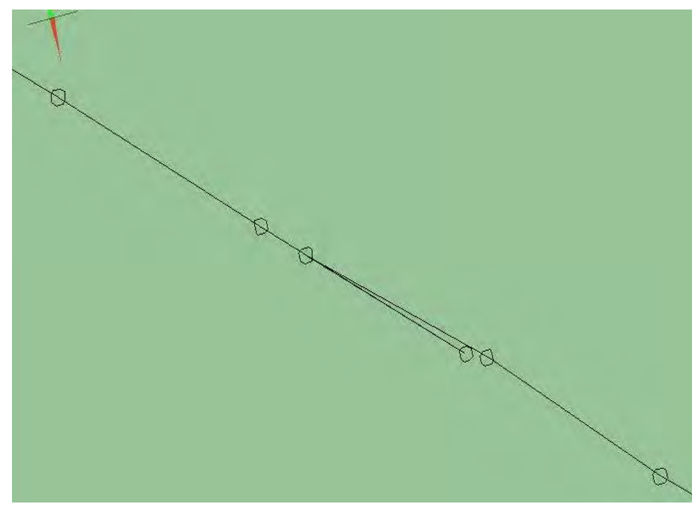


Figure 4 - Occasional small position jump backwards

erroneous positional data is very distinctive of the problem

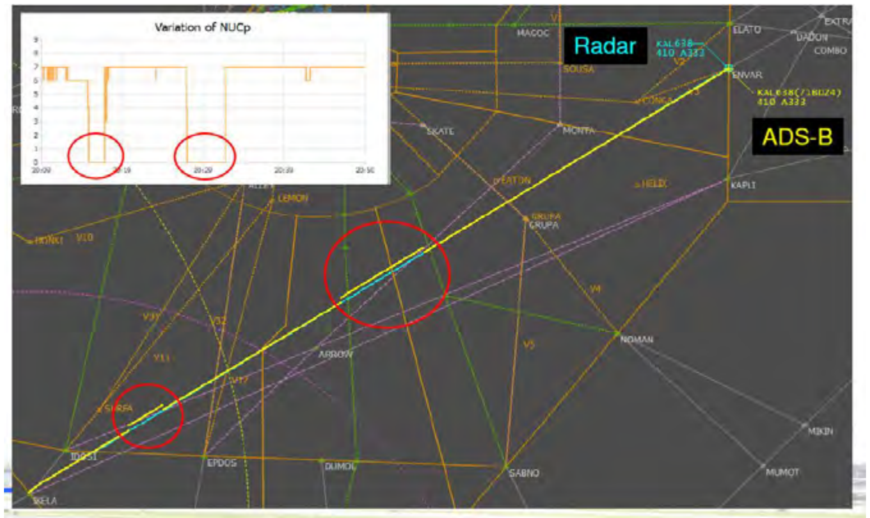


Figure 5 - NUC value toggling

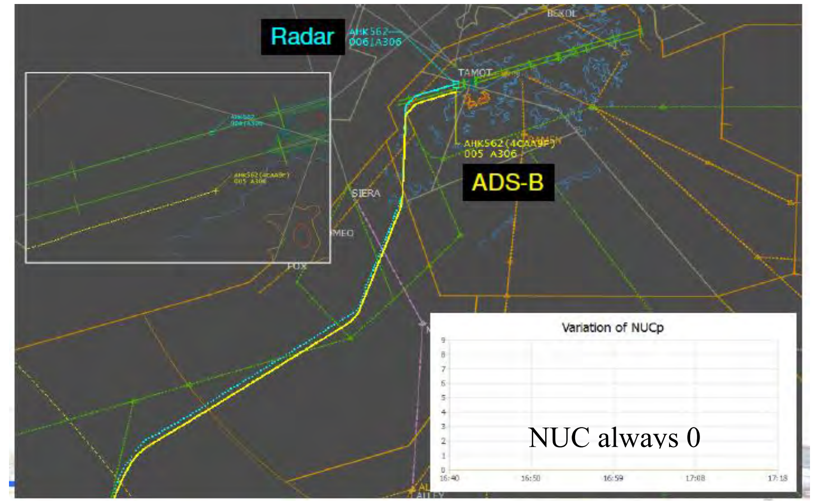


Figure 6 – Consistent low NUC

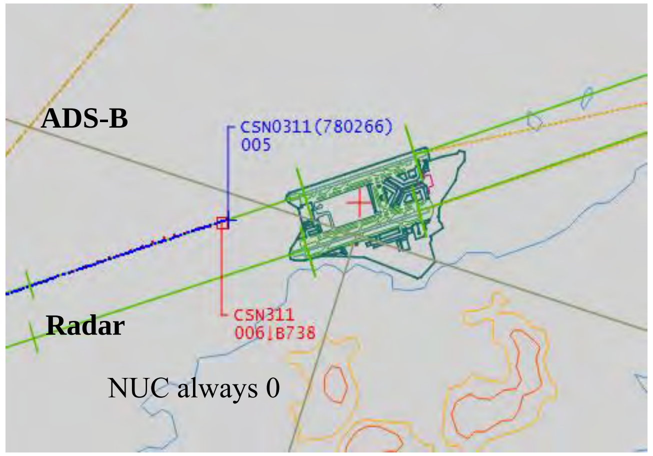


Figure 7a - Additional zero inserted

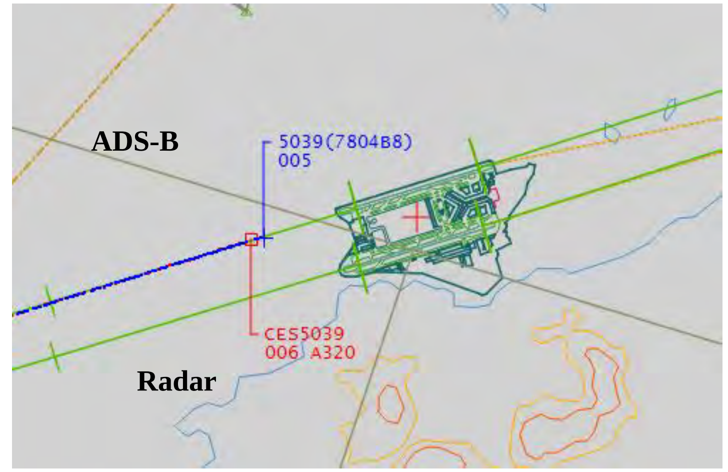


Figure 7b - ICAO Airline Designator Code dropped

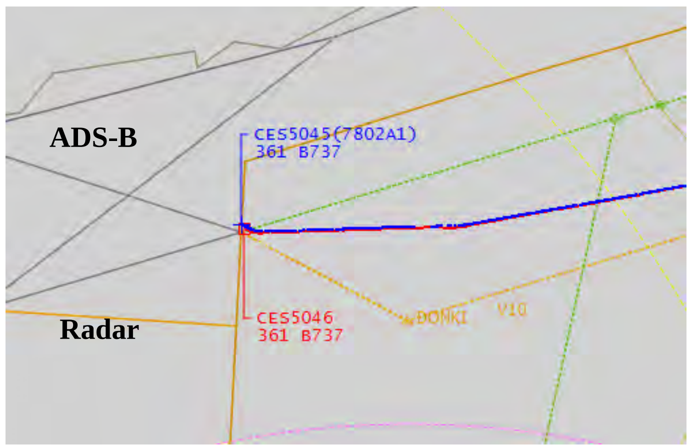


Figure 7c - Wrong numerical codes entered

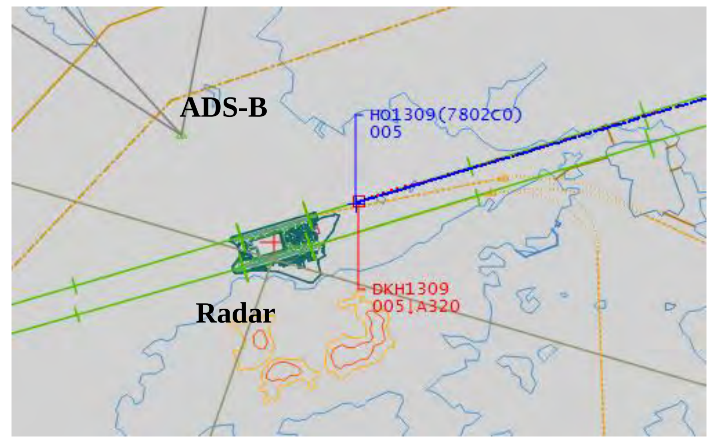
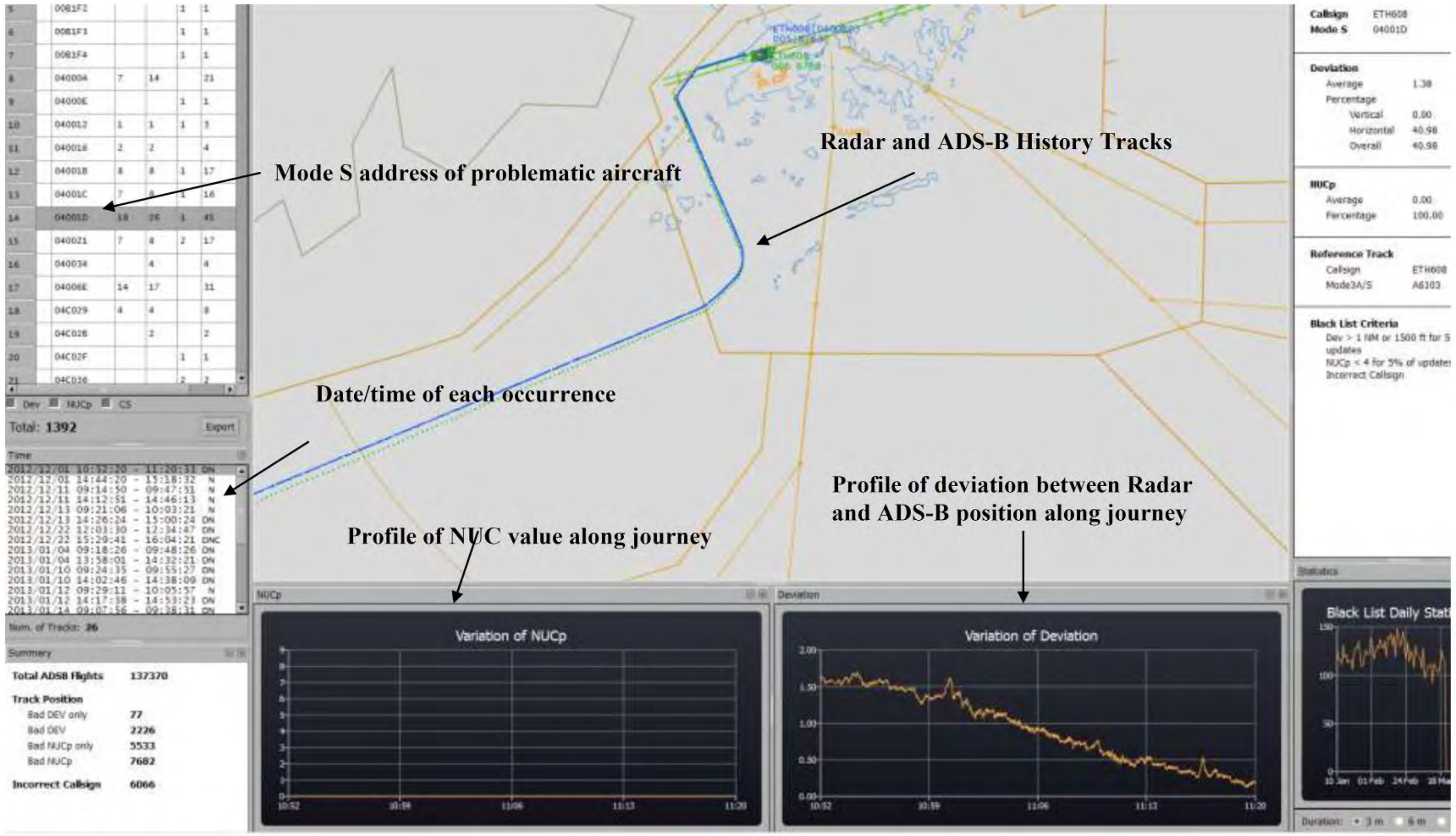


Figure 7d - IATA Airline Designator Code used

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



Appendix 3

A Template for ADS-B Mandate/Regulations for Aircraft Avionics

(1) On and after dd/mm/yyyy, if an aircraft carries 1090MHz extended squitter (1090ES) ADS-B transmitting equipment for operational use in xxxxxxxx territory, the equipment must have been certificated as meeting :[1]

(a) European Aviation Safety Agency - Certification Considerations for the Enhanced ATS in Non-Radar Areas using ADS-B Surveillance (ADS-B-NRA) Application via 1090 MHZ Extended Squitter (AMC 20-24), or
(b) European Aviation Safety Agency - Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance Subpart D — Surveillance (SUR) (CS-ACNS.D.ADS-B), or
(c) Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems, or
(d) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.

(2) On and after dd/mm/yyyy, if an aircraft operates on airways (insert routes)………..at or above FLXXX………(or in defined airspace boundaries ……………. at or above FLXXX):[2]

The aircraft must carry serviceable 1090MHz extended squitter (1090ES) ADS-B transmitting equipment that has been certificated as meeting :-

(a) European Aviation Safety Agency - Certification Considerations for the Enhanced ATS in Non-Radar Areas using ADS-B Surveillance (ADS-B-NRA) Application via 1090 MHZ Extended Squitter (AMC 20-24), or
(b) European Aviation Safety Agency - Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance Subpart D — Surveillance (SUR) (CS-ACNS.D.ADS-B), or
(c) Federal Aviation Administration – Advisory Circular No: 20-165A (or later versions) Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems, or
(d) the equipment configuration standards in Appendix XI of Civil Aviation Order 20.18 of the Civil Aviation Safety Authority of Australia.

(3) An aircraft carrying 1 090 MHz extended squitter (1090ES) ADS-B equipment shall disable ADS-B transmission unless:

(a) the aircraft emits position information of an accuracy and integrity consistent with the transmitted value of the position quality indicator; or
(b) the aircraft always transmits a value of 0 (zero) for one or more of the position quality indicators (NUCp, NIC, NACp or SIL); or

[1] This paragraph ensures all aircraft operating in the airspace, if equipped with ADS-B, are compliant to standards.

[2] This paragraph provides mandate requirements within certain parts of the airspace

(c) the operator has received an exemption granted by the appropriate ATS authority.

Note: States are urged to include at least the standards stated in the template. States may include other standards allowed by the State's regulations.

Appendix 4

An Example of Advice to Operators Concerning Inconsistency Between ADS-B Flight Planning and Surveillance Capability

1 Background

Newer technologies for aircraft surveillance are now available – such as Mode S and ADS-B – which in many aircraft are installed as replacements for older Mode A/C transponders.

Air Traffic Control makes use of these new capabilities, and uses the Flight Plan information as a decision support tool – to allow the Air Traffic Controller to predict the surveillance capability of a particular aircraft before it enters radar or ADS-B coverage.

Requirements for ADS-B and Mode S (**insert local reference document if applicable**) may mean that if flight planning does not accurately reflect the aircraft capability, services may be withheld (for example if ADS-B is mandatory, but not indicated on the flight plan **– this section to be modified for local requirements**).

2 Flight Planning Requirements for Transponder and ADS-B

The flight planning requirements for aircraft are described in **(local document reference or ICAO DOC 4444 Appendix 2)** and repeated below.

Surveillance Equipment

N if no surveillance equipment for the route to be flown is carried, or the equipment is unserviceable

OR

INSERT one or more of the following descriptors, to a maximum of 20 characters, to describe the serviceable surveillance equipment and/or capabilities on board:

SSR Modes A and C

A Transponder — Mode A (4 digits — 4 096 codes)

C Transponder — Mode A (4 digits — 4 096 codes) and Mode C

SSR Mode S

E Transponder — Mode S, including aircraft identification, pressure-altitude and extended squitter (ADS-B) capability

H Transponder — Mode S, including aircraft identification, pressure-altitude and enhanced surveillance capability

I Transponder — Mode S, including aircraft identification, but no pressure-altitude capability

L Transponder — Mode S, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability

P Transponder — Mode S, including pressure-altitude, but no aircraft identification capability

S Transponder — Mode S, including both pressure altitude and aircraft identification capability

X Transponder — Mode S with neither aircraft identification nor pressure-altitude capability

Note : Enhanced surveillance capability is the ability of the aircraft to down-link aircraft derived data via a Mode S transponder.

ADS-B

B1 ADS-B with dedicated 1 090 MHz ADS-B "out" capability[1]

B2 ADS-B with dedicated 1 090 MHz ADS-B "out" and "in" capability[1]

U1 ADS-B "out" capability using UAT

U2 ADS-B "out" and "in" capability using UAT

V1 ADS-B "out" capability using VDL Mode 4

V2 ADS-B "out" and "in" capability using VDL Mode 4

3 Additional information

The capability of your aircraft transponder, and ADS-B capability, will typically be available in the transponder manual, or in the aircraft flight manual for the aircraft. For General Aviation aircraft, the most common configurations for filing in the flight plan item10b will be (listed in order of capability).

EB1 – An ADS-B equipped aircraft would typically file this to indicate the Mode S transponder capability with ADS-B out.

S – The majority of Mode S transponders (without ADS-B) will support pressure altitude information and Flight ID transmission.

C – For aircraft with an older Mode A/C transponder – most of which provide pressure altitude capability.

Less common configurations in General Aviation will include:

[1] Based on current version of ICAO Doc 4444

H, LB1 or LB2 – Enhanced surveillance capability is more usually associated with higher end aircraft. ADS-B IN (B2) is relatively rare at this time, but may be available for some aircraft.

I, P or X – Most Mode S transponders will support Flight ID and pressure altitude, so these configurations are not common.

A – some low end GA aircraft may not provide pressure altitude information.

U1 or U2 – these ADS-B technologies are only authorized in a limited number of countries in the Asia Pacific Region.

Planning designations not to be used in Asia Pacific:

V1 or V2 – these ADS-B technologies are not authorised for use in Asia Pacific Region.

Remember:
Always flight plan the correct surveillance capability for your aircraft. If in doubt, consult the transponder manual, aircraft flight manual, or your Licenced Aircraft Maintenance Engineer.

Appendix 5

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

1 ADS-B Ground Station

Site Monitoring

- Receiver Sensitivity
- Antenna Cable
- GPS Health
- Coverage Check
- Probability of Detection
- Station Service Availability
- Receiver Status

Remote Control & Monitoring (RCMS)

- CPU Process Operation
- Temperature
- ASTERIX Output Load and Link Status
- Time Synchronization
- GPS Status
- Power Status
- Site Monitor Status
- Memory Usage
- Software Version (Operating System and RCMS Application)

Logistic Support Monitoring

- Record all failures, service outage and repair/return to service times

2 ADS-B Equipage Monitoring

- Update and maintain list of ADS-B equipped airframe details database
- Identify aircraft non-compliant to regional mandate

3 ADS-B Avionics Monitoring

- Track Consistency
- Valid Flight ID
- Presence of NACp/NIC/NUC Values
- Presence of Geometric Altitude
- Correctness of ICAO Aircraft Address

- Avionics Configuration and Connections
- Update and maintain list of aircraft with faulty avionics

4 ADS-B Performance Monitoring

- Percentage of aircraft with good integrity reports
- Accuracy of ADS-B Horizontal Position (Based on a reference sensor)
- Deviation between Geometric and Barometric Height
- Monitor the number of position jumps
- Message interval rate

5 ADS-B Display on ATC Display

- Split Track – ADS-B reported position might be off
- Coupling Failure – Wrong aircraft ID
- Duplicated ICAO Aircraft Address
- Display of data block

Appendix 6

BASELINE ADS-B SERVICE PERFORMANCE PARAMETERS

The following table provides guidelines for various performance requirements of ADS-B Category (Tier) 1, 2 or 3 services that States may consider when acquisition of an ADS-B managed service agreement with a service provider:

Service Parameter	**Guidance**	**Category 1 (Tier 1)** **5Nm separation capable commensurate with Radars (separation/vectoring/high performance with reliability, integrity & latency)**	**Category 2 (Tier 2)** **Situational awareness similar to ADS-C (safety-net alerts, SAR, supports procedural separation without voice, not 5nm separation)**	**Category 3 (Tier 3)** **Position Reporting with Enhanced Flight Operation**
Aircraft Updates	Recommended	0.5 second < Interval < 5 seconds as Operationally required	0.5 second < Interval < 20 seconds as Operationally required	0.5 second < Interval < 60 seconds as Operationally required
	Maximum	0.5 second < Interval < 10 seconds as Operationally required		
Network Latency	Recommended	95%: < 2 seconds of receiver-station output	95%: < 15 seconds of receiver-station output	95%: < 60 seconds of receiver-station output
Reliability 1	Recommended	2 autonomous receiver-stations including antenna, each providing data, no common point of failure	1 unduplicated receiver-station including antenna	1 unduplicated receiver-station including antenna
Reliability 2 - MTBF	Recommended	Each receiver-station including antenna to have MTBF >10,000 hrs	Each receiver-station including antenna to have MTBF >10,000 hrs	Each receiver-station including antenna to have MTBF >10,000 hrs
Reliability – Communications Infrastructure	Recommended	Completely duplicated, no common point of failure	Unduplicated, MTBF > 400 hrs	Unduplicated, MTBF> 200 hrs
Reliability – Total ADS-B Service	Recommended	Total Service MTBF >50,000 hrs	Total Service MTBF > 400hrs	Total Service MTBF> 200 hrs
Availability – Total ADS-B Service	Recommended	Total Service Availability > .999	Total Service Availability >.95	Total Service Availability >.90

Service Parameter	**Guidance**	**Category 1 (Tier 1)** **5Nm separation capable commensurate with Radars (separation/vectoring/high performance with reliability, integrity & latency)**	**Category 2 (Tier 2)** **Situational awareness similar to ADS-C (safety-net alerts, SAR, supports procedural separation without voice, not 5nm separation)**	**Category 3 (Tier 3)** **Position Reporting with Enhanced Flight Operation**
Integrity – Ground Station	Recommended	Site monitor System Monitoring	Site monitor System Monitoring	System Monitoring
	Minimum	System Monitoring	Not required	Not required
Integrity – Data Communications & Processing	Recommended	All systems up to ATM system, errors < 1 x 10E-6	All systems up to ATM system, errors < 1 x 10E-6	All systems up to ATM system, errors < 1 x 10E-6

The choice of category (tier) could be based upon a number of factors including the following,

a) The desired service
b) The available budget
c) The available ATC automation system & its capabilities and/or interim display systems
d) ATC training and ratings
e) Availability of appropriately tailored ATC procedures

States could initially choose one level and transition to another at a later time. For example, Category (Tier) 2 could be used to add additional safety nets/situational awareness and gain operational experience during the initial stage, moving later to a full separation service using Category (Tier) 1.

Note: The Performance Based Surveillance Sub Group of the ICAO Surveillance Panel is reviewing performance standards for surveillance systems generally. A future update to the requirements in the above table may be based on the outcomes of that panel.

Appendix 7

GUIDANCE MATERIAL ON
GENERATION, PROCESSING & SHARING of ASTERIX
CATEGORY 21 ADS-B MESSAGES
(Including Attachments A, B, C & D)

1. INTRODUCTION

1.1 The "All Purpose Structured Eurocontrol Surveillance Information Exchange" (ASTERIX) Category 21 is a data format standard globally accepted by the Air Traffic Management (ATM) system manufacturing industry for sharing of ADS-B data with ATM automation system.[8] Asterix Category 21 data is used to convey ADS-B data from ADS-B receiver stations to ATC processing and display system. This guidance material discusses various aspects of this process. Since the ASTERIX Category 21 edition 0.23 was issued in November 2003, it has undergone continuous revisions with some 19 subsequent editions. The focus of this guidance material is to concentrate on 1090ES ADS-B data using:

a) RTCA DO-260 (Version 0);
b) RTCA DO-260A (Version 1); and
c) RTCA DO-260B (Version 2)

1.2 The ASTERIX Category 21 edition 1.0 issued in August 2008 fully incorporated the DO260A standard while edition 2.1 issued in May 2011 fully incorporated the latest DO260B standard. The latest edition (as at April 2018) is edition 2.4.

2. ASTERIX CAT 21 IN ASIA AND PACIFIC REGIONS

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

3. CHOICE OF ASTERIX VERSION NUMBER

3.1 The Asterix standard has been developed over many years. Stability in the standard is desirable so that ADS-B receiver station designers and ATM automation designers and manufacturers can build interoperable systems with confidence. Because ADS-B technology has been evolving over the years, and will continue to do so, it is not surprising that the Asterix standard has also developed along with the ADS-B link technology standards to grasp the best benefits of its intended design.

3.2 During 2005, Asia Pacific decided to use Ed0.23 as the edition for sharing ADS-B data between states. This version provides adequate information so that useful ATC operational services can be provided including ATC 3 nautical mile and 5 nautical mile separation services. Ed0.23 can be used with DO260, DO260A and DO260B ADS-B avionics/receiver stations to provide basic ATC operational services. However, Ed0.23 cannot fully support all the capabilities offered by DO260A and DO260B.

3.3 Nearly all Ed0.23 data items can be "re-constructed" from a received Ed2.1 data stream. However, most of the special DO260A/B data items cannot be "re-constructed" from an Ed0.23 data stream. In terms of domestic use and data sharing with other ANSPs concerning ADS-B data, several options exist for ANSPs as follows:

Option	Domestic use	Data sharing
1	Ed0.23	Ed0.23. This is the default and basic standard.
2	Ed2.1	Ed0.23. This will require some conversions to occur, probably through an ADS-B format conversion and filter system (see Paragraph 11), between a domestic system and a foreign system. Difficulties may exist if the domestic ATM system requires special DO260A/B data items, since they cannot all be re-constructed from the external foreign Ed0.23 data stream.
3	Ed2.1	Ed2.1. Must negotiate bilaterally with data sharing partner regarding exact version to be used to achieve the intended functions.

Note: In this table, Ed2.1, a later DO260B compliant Asterix Cat 21 edition, is chosen as a representation of an Asterix Cat 21 edition after Ed0.23. There exists other Asterix CAT 21 editions (e.g. 0.26, 1.3, 2.4 etc.) after Ed0.23 that could be used by ANSPs for domestic and data sharing use.

4. SPECIFICATION OF ASTERIX MESSAGE PROCESSING

4.1 Care is needed to understand the difference in specifications:

4.2 **Asterix Cat 21**: Defines the characteristics of the data ON the interface including fields that are mandatory on the interface.

4.3 **ADS-B receiver station specifications**: To define the Asterix standard, the ANSP must also define which optional Asterix data items are required to be delivered on the Asterix interface, when the appropriate data is received from the aircraft. It is desirable that suppliers be required to:

a) indicate how the receiver station processes and outputs every received DO260, DO260A and DO260B data element into an Asterix data element/field; and

b) indicate which and how each Asterix data element and field presented at the output are populated.

4.4 **ATM automation system specifications:** Defines which received Asterix data element and fields are processed and how they are processed. Also defines which Asterix optional data fields are required by the ATM automation systems (if any). ANSPs that specify ADS-B receiver stations and ATM automation systems need to consider carefully and clearly about what they desire to achieve. Specifications which simply require compliance with a particular Asterix edition will be

[8] FAA utilise Asterix Cat 33 for ADS-B message distribution.

inadequate in most circumstances. In particular ANSPs, together with their suppliers should :

a) Specify the Asterix standard edition to be used. This defines the message formats that are placed on the link between ADS-B receiver station and downstream systems like ATM automation, recording & analysis systems, bypass ATC systems and foreign ANSPs. The edition will define which messages elements are mandatory in each message (very few fields) and a large number of optional fields. The optional fields can only be filled if relevant data is received from the aircraft. The optional fields will only be filled if the receiver station specification requires them to be filled.

b) Specify the ADS-B receiver station behaviour so that when data is received from the aircraft, the receiver station is required to fill appropriate optional Asterix data fields.

c) Specify the ATM automation system behaviour including appropriate semantic and syntax checks applied to the Asterix data, including any triggers for the system to discard data. The processing applied to each received Asterix data field should be specified. The ATC system should discard any messages with unexpected Asterix categories without discarding messages with known and defined Asterix categories.

5. MANDATORY FIELDS : ASTERIX AND 1090ES ADS-B

5.1 Asterix Cat 21 has been designed to support multiple datalinks. It has been defined to support data fields which are not available in the 1090ES standards. Therefore some data items and fields are not relevant when 1090ES is used.

5.2 The standard itself defines various items as optional or mandatory. This is defining what is ON the interface. It does NOT specify the behaviour of the transmitting receiver station nor the behaviour of the receiving ATM automation system.

5.3 When a single link technology has been chosen it may be sensible to diverge from the formal Ed0.23 standard to reduce the required Asterix datalink bandwidth. E.g.: in an environment with only 1090ES, it is unnecessary to transmit "Link Technology Indicator". Asterix Cat 21 Ed 2.1 allows this selection.

Data Items	Description	Mandatory (M) or Optional (O) items as per ASTERIX Category 21	
		Version 0.23 Specification	Version 2.1 Specification
I021/010	Data Source Identification	M	M
I021/030	Time of Day	M	N/A
I021/071 or I021/073	Time of Applicability of Position or Time of Message reception for position	N/A	One of these is must be transmitted
I021/040	Target Report Descriptor	M	M
I021/080	Target Address	M	M
I021/210	Link Technology Indicator/ MOPS version	M	O

6. GENERATION OF ASTERIX AT AN ADS-B RECEIVER STATION

6.1 The following general principles should be adopted:

6.2 Commensurate with link bandwidth availability, transmit all mandatory Asterix data items and also transmit those Asterix data items that are operationally desirable. That is, when the appropriate aircraft transmission is received by the ADS-B receiver station, the data should be transmitted to the ATC system for operational use or for technical recording and analysis use. If no aircraft transmission data is received to fill an Asterix data item during any update cycle, the data item should not be included in the Asterix data stream to reduce bandwidth requirements.

6.3 **Group 1 (Mandatory Data Items)**: An Asterix Cat21 message should not be transmitted unless the mandatory data items defined in Appendix A are all present.

6.4 **Group 2 (Desirable Data Items)** : The data items defined in Appendix B are operationally desirable which should always be transmitted in the Asterix Cat 21 messages whenever the data are received by the 1090ES receiver station from aircraft (if allowed by the relevant Asterix standard chosen).

6.5 **Group 3 (Optional Data Items)** : The data items defined in Appendix C are considered optional and may or may not need to be transmitted depending on availability of such data from aircraft and/or other specific operational needs.

6.6. **Group 4 (Future Data Items)**: The following data are defined in the DO260A and DO260B standards but are not yet defined in the Asterix standard. This group is provided for information only. It illustrates the need for system designers to provide for future adaptability when possible and when cost effective to do so. Not only will the Asterix standard continue to evolve, but changes to DO260 can also be anticipated within the decade.

a) Target heading: Information from DO260A/B Target state and status messages (On condition messages). These could be used for detection of pilot errors in selection of heading/altitude; and

b) GPS Offset: Could be used to more accurately display aircraft position on an airport surface, or better detect that an aircraft has passed an airport hold point.

6.7 When developing a specification for an ADS-B receiver station, it is considered necessary that the specification requires the transmission of all data items that are operationally desirable (Group 2), when such data are received from the aircraft, in addition to the data items that are mandatory (Group 1) in Asterix messages. Whether Group 3 optional data items will need to be transmitted or not should be configurable on item-by-item basis within the ADS-B receiver station depending on specific operational needs.

7. PROCESSING OF ASTERIX ADS-B DATA AT THE ATC SYSTEM

7.1 An Asterix Cat21 message should not be accepted by the ATC system for processing unless it includes at least all the Group 1 data items.

7.2 The ATC system should process all received Asterix Cat21 message data items that bring operational benefits (i.e. Group 2 data items). An ATM automation specification should require that the system appropriately process those Group 2 data items depending on specific operational need. Whether the ATC system will process Group 3 optional data items will depend on specific operational needs.

8. DATA SHARING OF ASTERIX ADS-B DATA

8.1 In principle, all data receiving from the shared ADS-B receiver station should be delivered to the receiving party as far as practicable without filtering, unless owing to technical reasons such as the need to convert the data from one ASTERIX format to another, or it is requested by the receiving party of the data.

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

9. ISSUE RELATED TO DO260A

9.1 Support of DO260A using Asterix Cat 21 Ed0.23

a) DO260A was developed after Ed0.23 of Asterix was defined. Therefore, Ed0.23 does not directly support DO260A. However, receiver station software can generate useful Ed0.23 Asterix data from DO260A reports through use of the following techniques;

b) A useful I021/090 Figure of Merit can be generated from DO260A messages. Some implementations have a table, which defines the FOM/PA to be generated for each combination of SIL, NIC and NAC. The contents of the table can be offline defined to generate the appropriate FOM/PA values. The downstream ATC system can then process DO260A reports as if they were DO260 reports; and

c) If there is a particular need for the ATC system to have access to the NIC/NAC or SIL or other data item that exist in DO260A (but not in DO260), then users may need to consider a more recent version of Cat 21.

9.2 Support of DO260A using Asterix Cat 21 Ed1.0 or Ed2.1 (or later versions)

a) When DO260A is used, then the ANSP could decide to use Asterix Cat 21 Ed1.0 (or later versions) or Ed2.1 (or later versions); and

b) Readers are invited to carefully examine the DO260A fields (see Appendix D) to determine if the benefits of additional DO260A fields are large enough to warrant adoption of Asterix Cat 21 Ed1.0 (or later versions) or Ed2.1 (or later versions).

10. ISSUE RELATED TO DO260B

10.1 Support of DO260B using Asterix Cat 21 Ed0.23

a) DO260B was developed some years after DO260A. Therefore, Asterix Cat 21, Ed0.23 does not directly support DO260B;

b) The same techniques used for processing DO260A can be used for processing DO260B, however, the table used must account for NIC supplement B & NIC supplement C, and may also wish to account for SDA; and

c) If there is a particular need for the ATC system to have access to the new data items offered by DO260B, then users may need to consider a more recent version of Cat 21 (e.g. Ed2.1 or later versions).

10.2 Support of DO260B using Asterix Cat 21 Ed2.1 or later versions

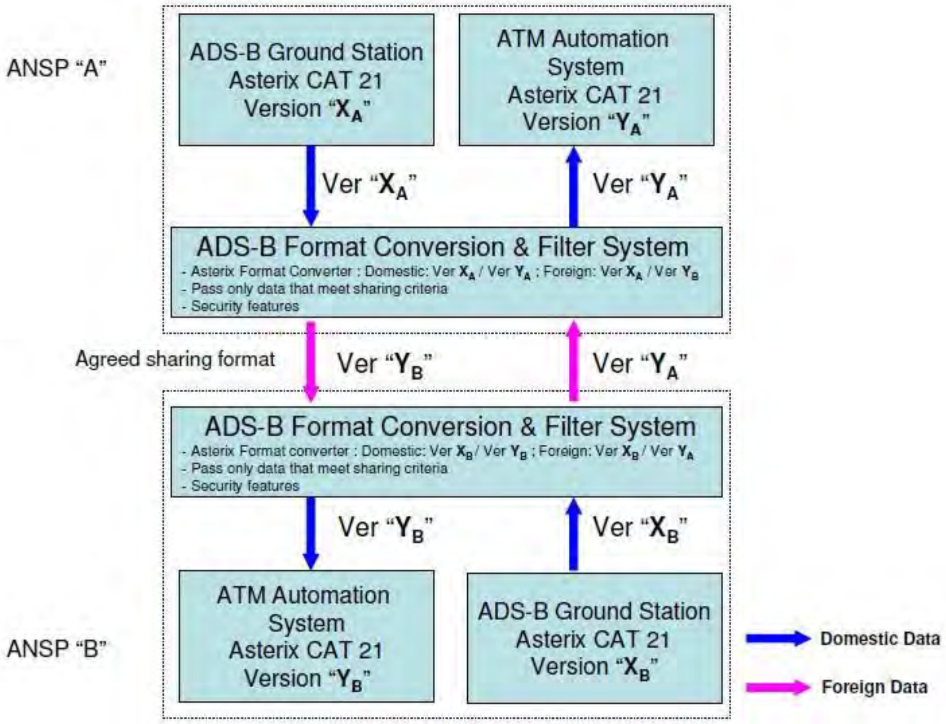
a) If DO260B is used, then the ANSP could decide to use Asterix Cat 21 Ed2.1 or later; and

b) Readers are invited to carefully examine the DO260B data items (see Appendix D) to determine if the benefits of additional DO260B data items are large enough to warrant adoption of Asterix Cat 21 Version 2.1 or later.

11. ADS-B FORMAT CONVERSION AND FILTER SYSTEM

11.1 It is clear that the evolution of 1090ES ADS-B transmission will continue. Avionics software will be upgraded to provide additional or changed functionality. As a result Asterix standards will also continue to evolve, and ATC systems will need to be adaptable to be able to cope with new functionality requirements and new message standards.

11.2 The use of an ADS-B format conversion & filter (ADS-B FC&F) system between domestic ADS-B systems and data shared with other states is a cost-effective way to provide the necessary protection and flexibility in this evolution. Such a system provides ADS-B format conversion between domestic and foreign ADS-B systems. While decoupling one ADS-B Asterix environment from another, the system allows information that meets specific sharing criteria to be passed through for data sharing. By doing so, loading on the ATM automation systems to process ADS-B data and bandwidth requires to transmit the ADS-B data could then be reduced. The system also allows independent domestic format changes without disruption to the foreign environment. A typical structure could be as shown below:



7 Attachment A - Group 1 (Mandatory Data Items)

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/010	Data Source Identification	X	X	Identifies source of data. Important if validity checks are performed as an anti spoofing capability. Validation that the data is received from an approved ADS-B receiverstation. Data received from a receiver station should not be processed if the position of the reported aircraft is an unreasonable distance away from the known location of the ADS-B receiver station. Where space based ADS-B is used and a nominal station location is defined, such range processing limits will need to account for the coverage supplied.
I021/030	Time of Day	X		Necessary to extrapolate the ADS-B data to time of display. Data received with a Time of Day too far in the past should be discarded. This data is too old.
I021/071 or I021/073	Time of Applicability of Position or Time of Message reception for position		X	Necessary to extrapolate the ADS-B data to time of display. Data received with a Time of Day too far in the past should be discarded. This data is too old.
I021/040	Target Report Descriptor	X	X	Indicates if report is a duplicate, on the receiver, is a simulated target, is a test target. This needs to be checked by ATC system prior to processing. If the data indicates that the report is a test target or a simulated target, it is normally processed differently to "real" targets.
I021/080	Target Address	X	X	Included in all 1090ES downlink messages, so always available. Used for report/report linkage in ATC tracking.
I021/090	Figure of Merit/Quality Indicators	X	X	Position cannot be used without quality indicator. If the quality of the positional data does not meet the requirements the data should be discarded.
I021/130	Position in WGS-84 co-ordinates	X	X	Report cannot be used without position

Attachment B - Group 2 (Desirable Data Items)

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/008	Aircraft operational status		X	TCAS capability, Target state reporting capability, CDTI capability, Single/dual aircraft antenna. It is desirable to have immediate knowledge of RA event.
I021/020	Emitter Category	X	X	Aircraft or vehicle type
I021/140	Geometric Altitude/Height	X	X	Useful for RVSM monitoring. Not normally used for ATC application. Could perhaps be used as an indicator of correct QNH setting in aircraft.
I021/145	Flight Level	X	X	Flight level is an important information to ATC
I021/155	Barometric Vertical Rate	X	X	Used for predictive tools and safety nets. Either Barometric vertical rate or Geometric vertical rate is provided by the aircraft – not both. However, the ATC system can calculate vertical rate from multiple flight level reports if these data items are not available.
I021/157	Geometric Vertical Rate	X	X	
I021/160	Ground Vector	X	X	Provides excellent vector to support extrapolation of positional data to time of display. However, the ATC system can calculate the velocity vector (ground vector) from multiple position reports. I021/160 however, is normally far superior that ATC system calculation.
I021/170	Target Identification	X	X	This is the callsign/Flight ID is extremely useful for ATC and matching to the flight plan (if any). Target identification is only sent once per 5 seconds. Some receiver stations designs attach the target identification (if known from previous recent downlinks) even if not received in the last 5 seconds. The field can be missing at the edge of ADS-B coverage – for flights inbound to coverage.

I021/200	Target Status	X	X	This is the emergency type and is highly desirable.

Attachment C - Group 3 (Optional Data Items)

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/077	Time of report transmission		X	Time of applicability is relevant for ATC system processing. Time of transmission is less relevant.
I021/032	Time of Day Accuracy	X		Maximum error in Time of day. Normally the maximum value is known by the ANSP because of station design.
I021/095	Velocity Accuracy	X		If using GPS, velocity accuracy will be adequate if the Position quality is accurate.
I021/072	Time of applicability of velocity		X	Can be managed by a velocity data time out in receiver station.
I021/075	Time of message reception of velocity		X	Normally velocity is in the same Asterix message as position. Velocity data time out in receiver station.
I021/161	Track number		X	Tracking can be performed by ATC system. Also the 24 bit code (aircraft address) could be used as a pseudo track number.
I021/110	Trajectory Intent	X	X	Defined in DO260 but not transmitted by any known product. Not defined in DO260A or DO260B
I021/146	(Intermediate) Selected Altitude	X	X	Target altitude : Information from DO260A/B Target state and status messages (On condition messages). These could be used for detection of pilot errors in selection of heading/altitude.
I021/148	Final State Selected Altitude	X	X	
I021/015	Service identification		X	Type of Service (VDL4, Ext Squitter, UAT, TIS-B VDL4, TIS-B Ext Squitter, TIS-B UAT, FIS-B VDL4, GRAS VDL4, MLT). Not useful to most ATC systems.
I021/016	Service management		X	Update rate or whether data driven output from GS. Normally known by receiver.

Data Items	Description	Ed 0.23	Ed 2.1	Remarks
I021/074	Time of message reception of position – high resolution		X	High resolution is designed to support MLAT system processing by receiver. Not required for pure ADS-B.
I021/076	Time of message reception of velocity – high resolution		X	High resolution is designed to support MLAT system processing by receiver. Not required for pure ADS-B.
I021/210	MOPS version/ Link Technology Indicator	X	X	Maybe useful for statistics about equipage. Not operationally relevant
I021/070	Mode 3/A code		X	Could be used for legacy ATC system that do not use Flight ID
I021/165	Rate of Turn/Track Angle rate	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/271	Surface capabilities and characteristics		X	
I021/132	Message amplitude		X	Useful for technical analysis. Not operationally relevant
I021/250	Mode S MB data		X	
I021/260	ACAS resolution advisory report		X	
I021/400	Receiver ID		X	
I021/295	Data ages		X	
I021/150	Air Speed	X	X	Defined in standards but only sent in absence Ground vector information. Can't be used for extrapolation unless wind speed known.
I021/151	True Air Speed	X	X	
I021/152	Magnetic Heading	X	X	Defined in standards but only sent in absence Ground vector information.
I021/220	Met Report	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/230	Roll Angle	X	X	Not transmitted in DO260, DO260A or DO260B messages
I021/131	Position in WGS-84 coordinates, high resolution		X	

Attachment D - Differences among DO260, DO260A, DO260B

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Introduction of Navigation Integrity Category (NIC) to replace Navigation Uncertainty Category (NUC_P)	NUC_P is used.	NIC is used to replace NUC_P.	More levels of NIC available. Vertical component removed.	NIC is shown in Ed1.0 and above. More levels of NIC (shown as PIC) are available in v2.1.	The additional quantum levels of NIC would allow the ANSP more flexibility in deciding whether the NIC is considered as 'good' (if required) However, for 3 NM & 5 NM separation with HPL 1Nm and 2 Nm respectively, this additional quantum is not useful.
Quality Indicator for Velocity (NUC_R and NAC_V)	NUC_R is used.	Replaced with NAC_V. Definition remains the same.	Vertical component removed.	Available in Ed0.23 and above.	Vertical component is not available for DO260B.
Surveillance Integrity Level and Source Integrity Level (SIL)	Not available.	Surveillance Integrity Level is used.	Renamed as Source Integrity Level. Definition is changed to exclude avionics fault.	Available in Ed1.0 and above.	The SIL will allow the user to further assess the integrity of the reported position (if required). NB: An implied SIL exists for DO260 aircraft if they always use GPS. However DO260 aircraft do not provide SIL.
System Design Assurance (SDA)	Not available.	Not available.	To address probability of avionics fault.	Available in Ed2.1.	The SDA will indicate the robustness of the system. ANSPs may decide on a minimum SDA for ADS-B services. If this action is taken then DO260 and DO260A aircraft will be unable to meet the criteria.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Navigation Accuracy Category (NAC_P)	Not available.	Derived from HFOM and VFOM.	Relies only on HFOM.	Available in Ed1.0 and above.	A reported accuracy is not provided by DO260. However, an estimated accuracy can be derived from NUC – assuming that NUC is HPL based.
Geometric Vertical Accuracy (GVA)	Not available.	Not available.	Derived from VFOM.	Available in Ed2.1.	Geometric altitude accuracy is not normally required for operational purposes.
Barometric Altitude Integrity Code (NIC_{BARO})	Not available.	To indicate integrity of barometric altitude.	Same as DO-260A	Available in Ed1.0 and above.	The NIC_{BARO} indicates the integrity of the barometric height. ANSPs could indicate to the controller that Barometric data has not been verified, however, aircraft without dual barometric systems/air data computers may be unable to provide a non zero NIC_{BARO} as data could be unnecessarily discarded.
Length / Width of Aircraft	Not available.	Provide an indication of aircraft size.	Same as DO-260A	Available in Ed1.0 and above.	The width / length indicate the size of the aircraft. This information may be used as an input for generating alerts on airport surface movement control.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Indication of capabilities	Only show status of TCAS and CDTI.	More information available including capability to send Air Reference Velocity, Target State and Trajectory Change reports. Status of Identity Switch.	Additional information on type of ADS-B in (i.e. 1090ES in or UAT in).	Available in Ed1.0 and above, except availability of 1090ES/UAT in and information on GPS antenna offset.	Indication on the availability of 1090ES in / UAT in may allow the controller to anticipate a potential request for in-trail procedure clearance. NB: ITP requires decision support aids which are more complex than ADS-B IN alone.
Status of Resolution Advisory	Not available.	Information on whether Resolution Advisory is active.	Same as DO-260A	Available in Ed1.0 and above,	Indication of the resolution advisory status allows the controller to know whether the pilots were alerted about the potential conflict.
GPS offset	Not available.	Indication on whether GPS offset is applied.	Information on GPS antenna offset is provided.	GPS offset status is available in Ed1.0 and above. Information on GPS offset is not available in ASTERIX	Indication on GPS offset may be one of the inputs for generating alerts on airport surface movement control.
Intention	Not available.	Able to indicate intended altitude and heading.	Same as DO-260A	Intended altitude is available in Ed0.23. Intended heading is not available in ASTERIX.	The intended heading and flight level can be used as an input to the trajectory prediction algorithm in the Short-Term Conflict Alert.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Target Status	Not available.	Not available.	Indication of Autopilot mode, Vertical Navigation mode, Altitude Hold mode, Approach Mode and LNAV Mode.	Vertical Navigation mode, Altitude Hold mode and Approach Mode are available in Ed 0.23 and above LNAV Mode is available in Ed2.1	The target status allows the controller to know the mode that the aircraft is in. i.e.: It could be presented to ATC.
Resolution Advisory	Not available.	Not available.	Availability of Active Resolution Advisories; Resolution Advisory complement record, Resolution Terminated; Multiple Threat encounter; Threat Type indicator; and Threat Identity data.	Available in Ed1.0 and above.	The Resolution Advisory will help the controller know the advisories that are provided to the pilots by the ACAS. This helps prevent the controller from giving instructions that are in conflict with the ACAS.

	DO-260	DO-260A	DO-260B	Availability of data in Asterix CAT 21	Potential uses of additional information
Mode A	DO260 change 1, allows this using test message in USA only. This was not implemented in actual products.	Broadcasted using test message in USA only.	Broadcasted worldwide as a regular message.	Available in Ed0.26 and above.	The Mode A allows flight plans to be coupled with the ADS-B tracks (supports legacy ATM automation system).

Appendix 8

ATTACHMENT to State letter SP 44/2-19/77

GUIDANCE ON 1 090 MHZ SPECTRUM ISSUES AND PROPER MANAGEMENT OF 24-BIT AIRCRAFT ADDRESSES ASSOCIATED WITH UNMANNED AIRCRAFT (UA)

Note. — This document is an unedited advance version of an ICAO publication as approved in principle, by the Secretary General, which is made available for convenience. The final edited version will be included in the next amendment to the Aeronautical Surveillance Manual (Doc 9924), which will be published in due course.

1. Background

1.1 The frequencies 1 030 and 1 090 MHz, acting as a frequency pair, support several aeronautical surveillance systems including secondary surveillance radar (SSR), multilateration (MLAT), airborne collision avoidance systems (ACAS) and automatic dependent surveillance-broadcast (ADS-B). Aircraft are interrogated by ground SSR/MLAT (or other aircraft, in the case of ACAS) on 1 030 MHz and reply (or broadcast) on 1 090 MHz with information such as their position, altitude and velocity vector.

1.2 The increasing density of ground-based and on-board surveillance systems using the 1 030/1 090 MHz frequencies is currently raising concerns, especially in dense airspaces. Ultimately it may result in a reduction to the overall performance of ACAS as well as the SSR/MLAT and ADS-B systems. In addition, the increased usage of ADS-B OUT applications for safety of life services and potential future evolution of those applications, such as space-based ADS-B, have raised serious concerns of potential congestion at 1 090 MHz. To ensure continued safe operation for all aircraft, proper and efficient utilization of available bandwidth at 1 090 MHz is required. This may include, when necessary, limiting access to 1 090 MHz by certain users.

1.3 Furthermore, it is important to note that those aeronautical surveillance systems rely on a limited capacity 24-bit aircraft address scheme. The allocation of a 24-bit aircraft address and its correct configuration in aircraft is a key element for safe operation of aircraft and associated protocols used to support communication and surveillance systems.

1.4 As defined in Annex 10 — *Aeronautical Telecommunications*, Volume III — *Communication Systems*, aircraft addresses are allocated in blocks by ICAO to the State of Registry or to the common mark registering authority. Using its allocated block of addresses, the State of Registry or the common mark registering authority assigns an individual aircraft address to each suitably equipped aircraft entered on a national or international register.

1.5 It is essential for States to recognize that their allocated block of 24-bit aircraft addresses is a finite and valuable asset. There are only 16 777 214 aircraft addresses in total and many of those have already been allocated to States of Registry or common mark registering authorities. Aircraft traffic growth has been forecast to double in the next 15 years and to manage these addresses in a sustainable manner, States need to validate whether new aircraft address allocation requests by aircraft operators fit the conditions defined in Annex 10, Volume III.

2. Issues identified in relation to operation of unmanned aircraft

2.1 As described above, concerns are being raised about congestion of the 1 090 MHz frequency and shortage of 24-bit aircraft addresses. The rapid growth in the number of UA is making those concerns more severe.

2.2 *Exponential increase of the safety risk due to 1 090 MHz congestion*

2.2.1 A recent study indicates that large numbers of UA (one UA per 2 square kilometres) operating at low level (less than 500 feet above ground level) in a typical high-density terminal airspace (760 ADS B-equipped aircraft operating within a 200 NM radius and from ground level to FL180) can interfere with ADS-B ground station reception of ADS-B reports when the transmit power of each UA is 1 watt or higher.

Note. — Some other studies indicate that even a low power (0.1W) transmission from large numbers of UA can reduce the coverage range of ADS-B.

2.2.2 All studies reviewed conclude that the operation of ADS-B OUT by a large number of UA raises a serious concern for the safety of other aircraft in the same airspace.

2.3 *Future depletion of 24-bit aircraft addresses*

2.3.1 The 24-bit aircraft address scheme was not designed for a very large number of aircraft. Some studies predict that based on the present growth of UA, there will be over a million such vehicles by 2025. Based on these current projections, it will be impossible to accommodate all UA in the current scheme.

2.3.2 In some situations UA may require a 24-bit aircraft address, for instance if the UA fly in controlled airspace or in proximity to traditional manned aircraft. States will need to evaluate such situations on a case-by-case basis when receiving a new aircraft address application from the UA community.

Note. — As described in the Manual on Remotely Piloted Aircraft Systems (RPAS) (Doc 10019), an aircraft which is intended to be operated with no pilot on board is classified as unmanned and an unmanned aircraft which is piloted from a remote pilot station is a remotely piloted aircraft (RPA) (refer to the following figure).

Figure 1-1 Unmanned aircraft

3. Procedure to ensure proper utilization of 1 090 MHz and for non-allocation of (24-bit) aircraft address for UA

3.1 There is increasing pressure to use 1 090 MHz Mode S or ADS-B OUT applications by UA. Given the large forecasted increase of UA and the fact that transmissions from their transponders or ADS-B OUT devices will impact the already congested use of 1 090 MHz by existing aeronautical surveillance and collision avoidance systems, States are urged to:

1) perform radio frequency spectrum analysis to analyse the degree of congestion of 1 090 MHz and, based on the outcome of this analysis, consider how 1 090 MHz ADS-B UA operations might impact the performance of the air navigation service provider (ANSP)-operated surveillance

systems in airspace of interest as well as the automatic collision avoidance systems on board aircraft operating in that airspace;

2) formulate the circumstances and define procedures to determine the potential requirement for 1 090 MHz ADS-B OUT equipage on UA in order to allow or prohibit such equipage as appropriate. During this process, States should consider:

- the degree to which individual UA may or may not require air traffic services. For example, a UA operating in uncontrolled airspace may not be required to use ICAO-compliant aeronautical surveillance systems; and

- the degree to which the operation of individual UA may or may not interoperate in the airspace with traditional manned aircraft. For example, if UA are not operating in proximity to traditional manned aircraft, then the use of ICAO-compliant aeronautical surveillance equipment by UA may not be justified.

3) in cases where UA are not required to equip with ICAO-compliant aeronautical surveillance equipment, States should not allocate 24-bit aircraft addresses.

Note. — 24-bit aircraft address allocation should be a part of the UA registration or operator approval process. For guidance material on reliable usage of 24-bit aircraft addresses, refer to Annex 10, Volume III and Doc 9924.

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