International Civil Aviation Organization

AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST SEMINAR AND ELEVENTH MEETING OF AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B SITF/11)

Jeju, Republic of Korea, 24-27 April 2012

Agenda Item 6: Review States' activities and interregional issues on trials and implementation of ADS-B and multilateration

AMC-20-24 IN A RADAR ENVIRONMENT

(Presented by Australia)

SUMMARY

This paper considers whether AMC20-24 aircraft can be used in an ADS-B RAD environment.

1. Background

1.1 There has been debate about whether AMC20-24 certified aircraft can receive ADS-B services when the ATC service also includes radar (i.e.: in a RAD environment). This doubt arises because AMC-20-24 defines a means of airworthiness and operational approval of the "Enhanced Air Traffic Services in Non-Radar Areas using ADS-B Surveillance" (ADS-B-NRA) application – and does not refer to a RAD service.

2. ICAO Circular 326[1]

2.1 ICAO Circular 326 "Assessment of ADS-B and Multilateration Surveillance to Support Air Traffic Services and Guidelines for Implementation" Appendix C defines the key performance requirements to support the claim that ADS-B is as good as a reference radar. The circular does NOT distinguish between radar and non radar environments. This is because the SEPARATION AND AIRSPACE SAFETY PANEL (SASP) does not consider that the requirements for radar and non radar environments are different for the following reasons:

- If an ADS-B sensor input to ATC is as accurate and reliable (accuracy/availability/continuity) as radar, then a mixed radar/ADS-B ATC display will be no worse than a radar/ radar ATC display. Multisensor ATC systems using radar have been operational for some decades.

[1] Agreed by SASP and currently in the publishing pipeline. Intended replacement for ICAO Circular 311

- The requirements for accuracy, integrity & latency do not change as a function of aircraft density. The requirements to separate just 2 aircraft are the same as those required to separate 50 aircraft.[2] The radars specified for dense environments do not have different accuracy or integrity requirements compared to less dense areas.

- The separation minimum is always determined between two aircraft and applied that way. A controller may have to 'separate' 50 aircraft, but that is done by applying minimums between pairs. The more pairs that need 'separating' becomes a controller workload issue. The accuracy, integrity and latency requirements don't change for the pair separation. However additional controls to minimise risk associated with increased workload and controller/system capacity could be required in a 'high density' airspace environment (as they could be in a more dense radar environment). These additional requirements should be tested against a localised safety assessment, not imposed as a global standard.

- If an ADS-B sensor input to ATC is as reliable (availability/continuity) as a radar, then a mixed radar / ADS-B system will be no worse than a radar/ radar ATC display[3].

    - In some environments, one could argue that ADS-B service reliability could be relaxed in a RAD environment, compared to ADS-B alone, because radar is available as a backup.

- If an ADS-B sensor input to ATC has an update rate and total latency[4] to the controller screen as good as a radar, then a mixed radar / ADS-B system will be no worse than a radar/ radar ATC display system

Some States may have special requirements because of the way in which radar is used however, these requirements are beyond the minimum required by ICAO.

2.2 The key performance parameters outlined in Circular 326 are shown below in Table C1.

[2] This SASP position is not agreed by Eurocontrol
[3] This ADS-B service reliability (availability/continuity) includes the ability of the system to deliver ADS-B data with adequate quality indicators. A loss of service through poor GPS geometry is a loss of the ADS-B service. Further, it can be a loss that affects multiple aircraft.
[4] Uncomenstated latency is also an important criteria when considering the accuracy of the data displayed on screen to the controller.

Table C-1: SASP comparative assessment

	Characteristic	Minimum Requirement 3 NM	Minimum Requirement 5 NM
1.	Position: Accuracy	A 95 percentile accuracy of 0.3 nautical miles This can be represented by either: a) Navigation Accuracy Category (position) = 6 or better; or b) Navigation Uncertainty Category = 5 (for GNSS derived positional data only)	A 95 percentile accuracy of 0.5 nautical miles This can be represented by either: a) Navigation Accuracy Category (position) = 5 or better; or b) Navigation Uncertainty Category = 4 (for GNSS derived positional data only)
2.	Position: Integrity	A containment radius of <1 NM and the likelihood of the position error exceeding containment radius of 1e - 5 This can be represented by either: a) Navigation Uncertainty Category = 5 or better; or b) Navigation Integrity Category = 5 (or better) and Surveillance Integrity Limit = 2 (or better)	A containment radius of <2 NM and the likelihood of the position error exceeding containment radius of 1e - 5 This can be represented by either: a) Navigation Uncertainty Category = 4 or better; or b) Navigation Integrity Category = 4 (or better) and Surveillance Integrity Limit = 2 (or better)
3.	Position: Latency	4 seconds	4 seconds
4.	Position: Update Rate	5 seconds	12 seconds

Note.– For the provision of separation services to aircraft equipped with DO260 avionics, a State may select lower encoded values for NUC in relation to accuracy and integrity when it is demonstrated by safety assessment that the 95 percentile accuracy, and containment radius values, identified in Table C-1 will continue to be met.

3. AMC 20-24

3.1 ICAO AMC20-24 defines a means of airworthiness and operational approval of the "Enhanced Air Traffic Services in Non-Radar Areas using ADS-B Surveillance" (ADS-B-NRA) application. The AMC is built on the requirements defined in ED126/RTCA303 for the non radar environment.

3.2 If an aircraft is certified to AMC20-24 it satisfies the following critical performance requirements and meets the specified functionality.

Appendix 3: Summary of ADS-B-NRA Airborne Safety and Performance Requirements

Parameter	Requirement
Horizontal Position and Horizontal Position Quality Indicator(s)	10^{-5}/fh
ADS-B System Continuity	$2*10^{-4}$/fh
Horizontal Position Latency[1]	1.5 sec/95%

Table 1: Overall Minimum Airborne ADS-B System[2] Requirements

Parameter	Requirement
Horizontal Position Source	
• Accuracy (95%)	• 5 NM Sep: 926 m
• Integrity	
• Containment Radius (Rc)	• 5 NM Sep: Rc=2 NM
• Source Failure Probability	10^{-4}/h[3]
• Alert Failure Probability	10^{-3} (per position source failure event)
• Time to Alert	• 5 NM Sep: 10 sec

Table 2: Minimum Horizontal Position Source Requirements

Note: *for DO-260 based ADS-B transmit systems, the related encoding of the horizontal position quality indicator through the Navigation Uncertainty Category (NUC) effectively leads to a containment radius requirement of 1NM for a 5 NM separation service.*

Note: *accuracy and integrity containment radius requirements are expressed here as guidance to related horizontal position source regulation (refer to section 8.4).*

Note: *the containment bound requirements reflect the outcomes of both the collision risk assessment (CAP) and time-to-alert assessment.*

Note: *the accuracy and integrity containment radius requirements have to be met by the horizontal position source, taking into account the effects of on-board latency (if not compensated for).*

An uncompensated latency of 1.5 seconds translates into a dilution in the order of 450 metres (assuming an aircraft speed of 600 knots in en-route airspace). This value of 450 metres has to be added to the actual performance of the horizontal position source(s), the sum of which has to be within the required bounds.

The GNSS equipment specified in 8.4.6 meets the overall accuracy and integrity requirements, including the effects of an uncompensated latency of maximum 1.5 second accumulated up to the time of transmission.

A number of other key "features" of AMC20-24 are that it:

- Requires an adequate positional data source and associated quality indicators
- Requires NUC/NIC=0 transmission when position cannot be calculated or integrity cannot be provided
    - allows[5] NUC to be based on HFOM in rare satellite constellation circumstances leading to the temporary unavailability of the integrity monitoring (RAIM) function
- Defines the minimum necessary parameters be transmitted
    - Which does not require all emergency codes[6]
    - Which does not require mode A code (However, aircraft identification (FlightID) is transmitted)

4. An AMC20-24 approved aircraft meets the requirements defined in ICAO Circular 326

4.1 An aircraft certified to AMC-20-24 meets the critical **minimum** performance characteristics required and discussed in ICAO Circular 326. However, States need to consider their own environments in their safety assessment. In particular, the local safety assessment needs to consider the architecture and functionality of the ATC surveillance system, local ATC procedures (in particular with respect to aircraft identification) and the acceptable "reference radar" performance (incl. the consideration of appropriate "ranges of applicability" for comparison with the chosen reference radar).

4.2 It must be noted that the ATC system is required to filter out aircraft reports which do not have adequate accuracy/integrity to meet the needs of the ATC objective.[7] All ADS-B certified aircraft can generate low quality ADS-B reports if there is inadequate GPS geometry.

[5] Under the assumption that the implementing ANSP has performed a supporting analysis, but noting that some supporting analysis is provided at Appendix G of DPO303

[6] Under that assumption that appropriate operational procedures have been established by the implementing ANSP;

[7] All recognised standards require that NIC/NUC integrity reports be used to filter out (and discard) data with inadequate qulaity.

	ICAO Requirement 3 NM RAD/NRA	**ICAO Requirement 5 NM RAD/NRA**	**AMC20-24 certified aircraft**
Positional accuracy	NAC=6 or better NUC=5 or better	NAC=5 or better NUC=4 or better	Aircraft doesn't determine accuracy. It is largely determined by satellite geometry. ATC system determines if AMC20-24 certified aircraft meets the requirements at a particular time by examining NAC/NUC
Position integrity	NIC=5 or better NUC=5 or better	NIC=4 or better NUC=4 or better	Aircraft doesn't determine integrity. It is largely determined by satellite geometry. AMC20-24 requires that it calculate integrity "properly". ATC system determines if AMC20-24 certified aircraft meets the requirements at a particular time by examining NIC/NUC
Position latency	4 seconds	4 seconds	AMC20-24 certified aircraft achieves uncompensated latency of 1.5 second 95%.
Position update rate	5 seconds	12 seconds	AMC20-24 certified aircraft transmits position every half second. ATC system ensures update rate to controller is better than 12 seconds.

5. AMC20-24 approved aircraft and RTCA/Eurocae RAD requirements

5.1 An aircraft certified to AMC-20-24 meets most requirements of European (EUROCAE ED161) and USA (RTCA DO318) documents for the "RAD" radar environment. Some exceptions are as follows:

- DO318/ED161 requirements include a maximum uncompensated latency of 0.6 seconds (instead of 1.5 seconds for AMC 20-24). [8]
- DO318/ED161 (&DO303/ED126) requires transmission of individual emergency codes instead of generic EMG code, however AMC20-24 does not[9]
- DO318/ED161 requires transmission of Mode A code.
- DO318/ED161 requires that the same data sources (eg: same altitude encoder) are used for ADS-B transmissions as for SSR

5.2 Whilst ICAO Circular 326 does not require the above exceptions for delivery of ADS-B services in a RAD environment, States should consider in their safety assessment whether the items above are necessary for their application and environment.

5.3 In addition, DO318/ED161 requires more demanding accuracy & integrity thresholds be used in the ATC ground system. This does not impact useability or not of AMC20-24 aircraft, depending on the achievable continuity of service of the minimum AMC 20-24 GNSS receiver.

[8] An additional 0.9 seconds could result in an additional along track error of 0.125Nm for an aircraft at 500 kts. This along track error should be considered as part of the Horizontal Position Accuracy requirement.

[9] AMC20-24 assumes that "Transmission of generic emergency indicator only : In order to mitigate the transmission of only the generic emergency indicator (and not also the discrete codes selected by the flight crew), It is assumed that appropriate operational procedures have been established by the implementing ATSP and that pilots and controllers have been trained in their use.

5.4 In this regard, it can be noted that from a GNSS receiver perspective (where accuracy & integrity are generated), the European rulemaking - SPI IR (and the related emerging EASA CS-ACNS) require ETSO-129A as a minimum standard - which is in line with AMC 20-24.

Furthermore, DO318/ED161 requires that the ATC ground system implements:

- Same aircraft identification by SSR and ADS-B;
- SSR/ADS-B data association and consistency checking between various data items.

6. Recommendation

6.1 It is recommended that the meeting note that:

a) When combined with adequate ATC system and ground station processing, which discards ADS-B data with inadequate quality indicators, AMC20-24 certified aircraft can meet (and exceed) the minimum performance requirements of ICAO Circular 326; and

b) The local implementation safety case must assess whether AMC20-24 is adequate for the application and environment envisaged.

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