International Civil Aviation Organization

MIDANPIRG Communication Navigation and Surveillance Sub-Group (CNS SG)

Sixth Meeting
(Tehran, Iran, 9 – 11 September 2014)

Agenda Item 3: Global and Regional Developments related to CNS

GLOBAL AND REGIONAL DEVELOPMENTS RELARED TO CNS

(Presented by the Secretariat)

SUMMARY

This paper presents the global and regional developments related to CNS, mainly the Regional Dashboards and Amendments to Annex 10.

Action by the meeting is at paragraph 3.

REFERENCES

- GANP DOC 9750
- ICAO Assembly 38th Session
- ICAO SL Ref.: AN 7/1.1.49-14/21
- ICAO SL Ref.: AN 7/1.3.102-14/36

1. INTRODUCTION

1.1 The ICAO 38th Assembly was held in Montreal, Canada, from 24 September to 4 October 2013, endorsed the Fourth Edition of Global Air Navigation Plan (GANP). The GANP incorporates the Aviation System Block Upgrade (ASBU) methodology which is a programmatic and flexible global systems engineering approach that allows all Member States to advance their Air Navigation capacities based on their specific operational requirements. The Block Upgrades will enable aviation to realize the global harmonization, increased capacity, and improved environmental efficiency that modern air traffic growth now demands in every Region around the world.

2. DISCUSSION

2.1 The 38th Assembly called upon States, Planning and Implementation Regional Groups (PIRGs), and the aviation industry to:

- utilize the guidance provided in the GANP for planning and implementation activities which establish priorities, targets and indicators consistent with globally-harmonized objectives, taking into account operational needs; and

- provide timely information to ICAO, and to each other, regarding the implementation status of the GANP, including the lessons learned from the implementation of its provisions.

2.2 The 38th Assembly urged States:

- to take into consideration the GANP guidelines as an efficient operational measure for environmental protection; and

- that are developing new generation plans for their own air navigation modernization to coordinate with ICAO and align their plans so as to ensure global compatibility and harmonization.

2.3 The contents of the GANP are three (3) chapters (Policy, Implementation and Aviation System Performance) and seven (7) Appendices. The Appendix 4 relates to Frequency Spectrum Considerations and Appendix 5 Technology Roadmaps for CNS, IM and Avionics. An extract is provided at **Appendix A** to this working paper.

2.4 The meeting may wish to recall that the 38th Assembly approved the Regional Performance Dashboards. These Dashboards aim to provide a glance of both Safety and Air Navigation Capacity and Efficiency strategic objectives, using a set of indicators and targets based on the regional implementation of the Global Aviation Safety Plan (GASP) and the Global Air Navigation Plan (GANP). The Dashboards are available on the ICAO website.

2.5 The purpose of these Dashboards is to show targeted performance at the regional level and, initially, contain graphics and maps with a planned expansion to include the Aviation System Block upgrades (ASBU) Block 0 Modules. The ICAO website will allow the visualization of the status of implementation through dynamic and interactive charts. This system will generate ad-hoc reports and enable an easy transformation of the dataset into the Regional Performance Dashboard and the annual Global Air Navigation Report. The Dashboards were made available to public at website: at http://www.icao.int/safety/Pages/Regional-Targets.aspx.

2.6 The Air Navigation Dashboard (V 1.0) contains the following Metrics:

a) implementation of PBN Approaches at International Aerodromes Runways;
b) utilizing of Air Traffic Flow Management (ATFM) Systems;
c) implementation of Aeronautical Information Management (AIM); and
d) implementation of Ground-Ground Digital Coordination/Transfer.

2.7 It is to be noted that the Dashboard are evolving and will have more information in particular "Continuous Descent and Climb Operations (CCO/CDO) and Fuel Savings/CO2 Emissions Reduction due to ASBU Implementation.

2.8 Amendment 89 to the International Standards and Recommended Practices, Aeronautical Telecommunications (Annex 10 to the Convention on International Civil Aviation) was adopted by the Council at the Fourth meeting of its 201st Session on 3 March 2014, available at **Appendix B** to this working paper.

2.9 The Air Navigation Commission, at the eighth meeting of its 195th Session held on 6 March 2014, considered proposals developed by the Navigation Systems Panel (NSP) Working Group of the Whole to amend the Standards and Recommended Practices (SARPs) in Annex 10 — Aeronautical Telecommunications, Volume I — Radio Navigation Aids concerning the Global Navigation Satellite System (GNSS) available at **Appendix C** to this working paper.

2.10 The meeting may wish to note that ICAO published Cir 326, "*Assessment of ADS-B and Multilateration Surveillance to Support Air Traffic Services and Guidelines for Implementation*".

2.11 The Circular provides details of a comparative assessment undertaken by the Separation and Airspace Safety Panel (SASP) that concludes that ADS-B and MLAT can be used to provide ATS surveillance, including separation, subject to certain conditions. The SASP assessment concluded that ADS-B can be used to provide a five Nautical Mile (5 NM) minimum, subject to certain conditions being satisfied. Furthermore, for guidance to States, an implementation roadmap and answers to frequently asked questions are included in the circular in Chapter 4.

2.12 Monitoring of the deployment of State or regional implementations of ADS-B and MLAT by ICAO is anticipated.

3. ACTION BY THE MEETING

3.1. The meeting is invited to note the information contained in this working paper and take into consideration the global and regional developments related to CNS when developing their national plans.

Appendix 4: **Frequency Spectrum Considerations**

Frequency spectrum availability has always been critical for aviation and is expected to become even more critical with the implementation of new technologies. In addition to the five technology roadmaps pertaining to communication, navigation, surveillance (CNS), information management (IM) and avionics, a global aviation spectrum strategy for the near-, medium- and long-term must support implementation of the GANP.

A long-term strategy for establishing and promoting the ICAO position for International Telecommunication Union World Radiocommunication Conferences (ITU WRCs) was adopted by the ICAO Council in 2001. The strategy prescribes the development of an ICAO position on the individual issues detailed in the agenda of an upcoming WRC, developed in consultation with all ICAO Member States and relevant international organizations. The strategy also includes a detailed ICAO policy on the use of each and every aeronautical frequency band. The policy is applicable to all frequency bands used for aeronautical safety applications. An overall policy and a set of individual policy statements for each aviation frequency band can be found in Chapter 7 of the *Handbook on Radio Frequency Spectrum Requirements for Civil Aviation*, including the *Statement of Approved ICAO Policies* (Doc 9718).

Both the position and the policy are updated after each WRC and approved by the ICAO Council. The strategy for developing the position and policy can presently be found in Attachment E to Doc 9718.

The ICAO position and policy for the ITU WRC horizon extends beyond the 15-year timeframe of the current GANP and anticipates the development of the future aviation system. However, based on the outcome of WRC 12, the ASBU Modules and the technology roadmaps, an update of the strategy for frequency spectrum will be managed by ICAO to anticipate changes and define safe mechanisms for redundancy between essential components of the future Air Navigation system.

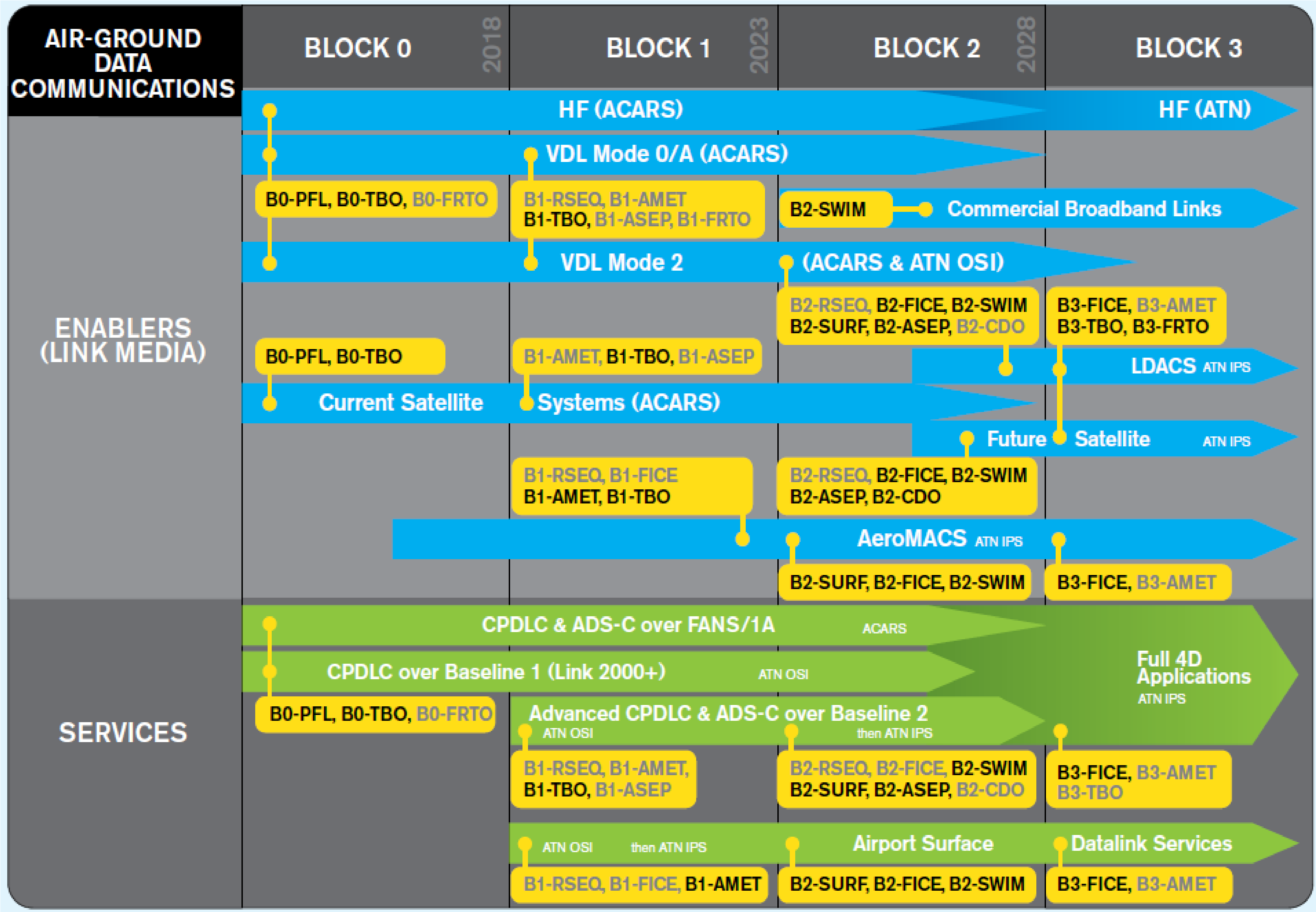
Future Aviation Spectrum Access

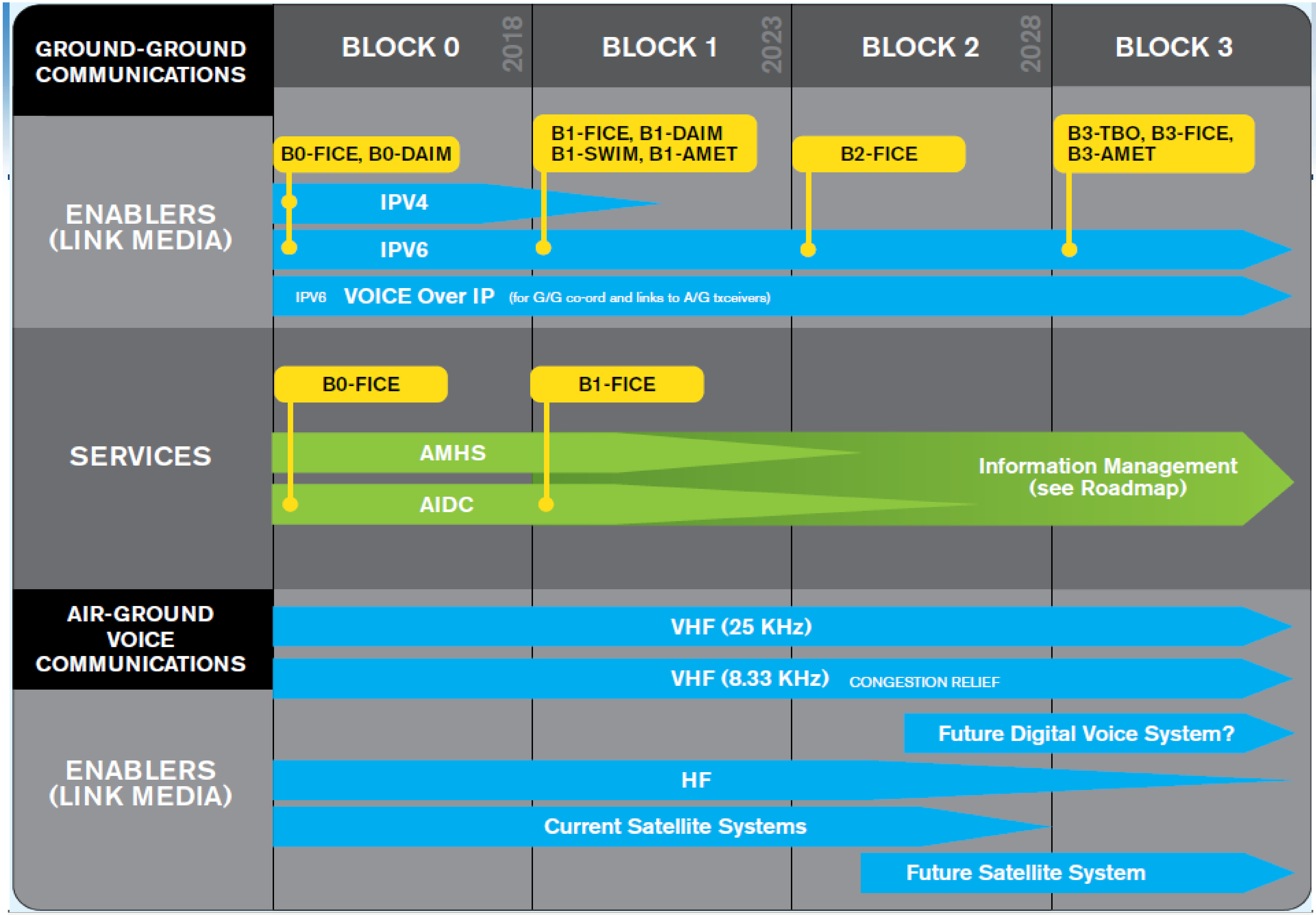
Due to the constraints specific to frequency allocations suitable to support safety-of-life critical services, little growth is foreseen in the overall size of aeronautical allocations in the longer term. However, it is vital that conditions remain stable in the existing frequency bands, to support continued and interference free access to support current aeronautical safety systems for as long as required.

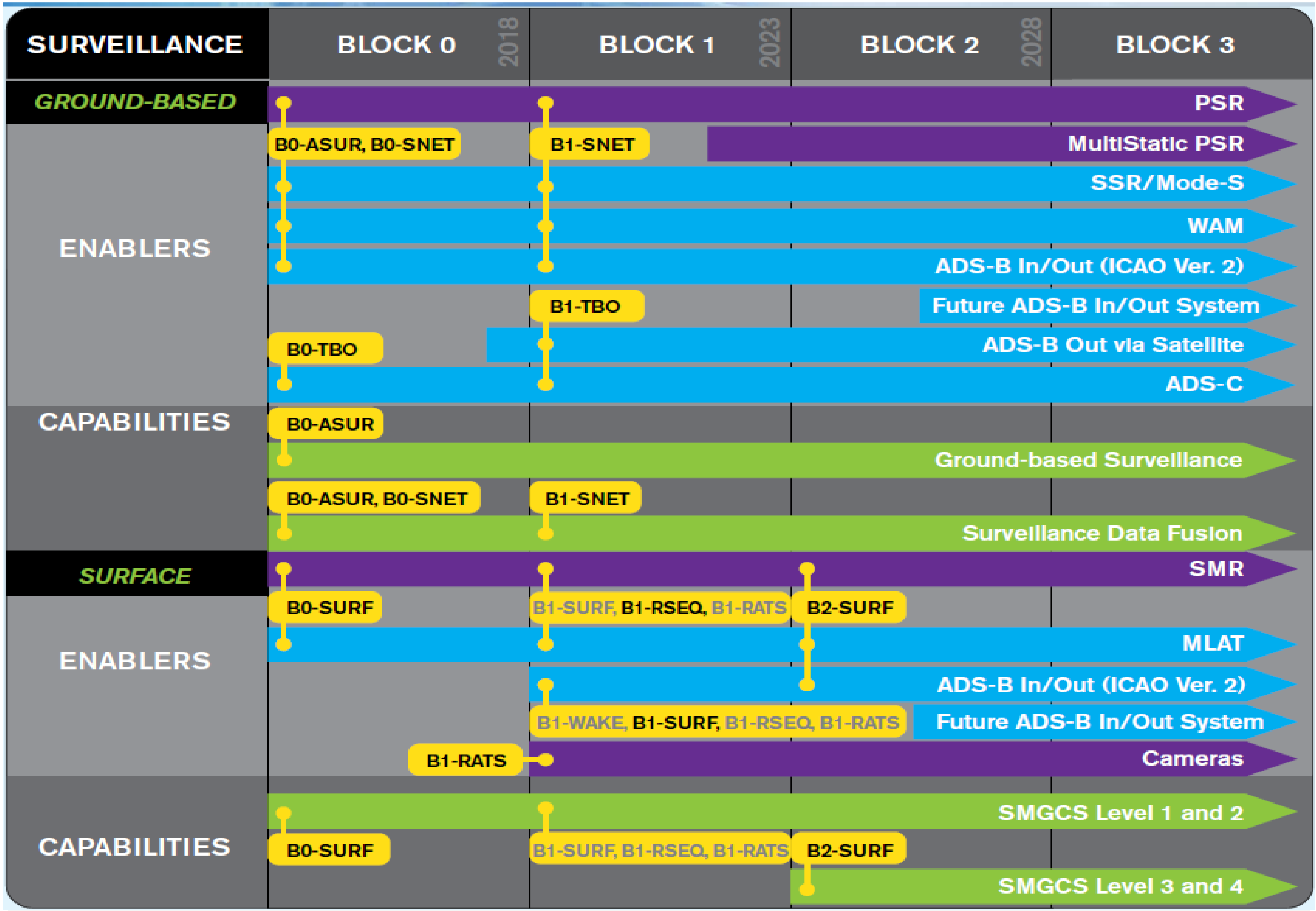
Similarly, it is vital to manage the limited aviation spectrum resource in a manner which effectively supports the introduction of new technologies when available, in line with the ASBU Modules and the technology roadmaps.

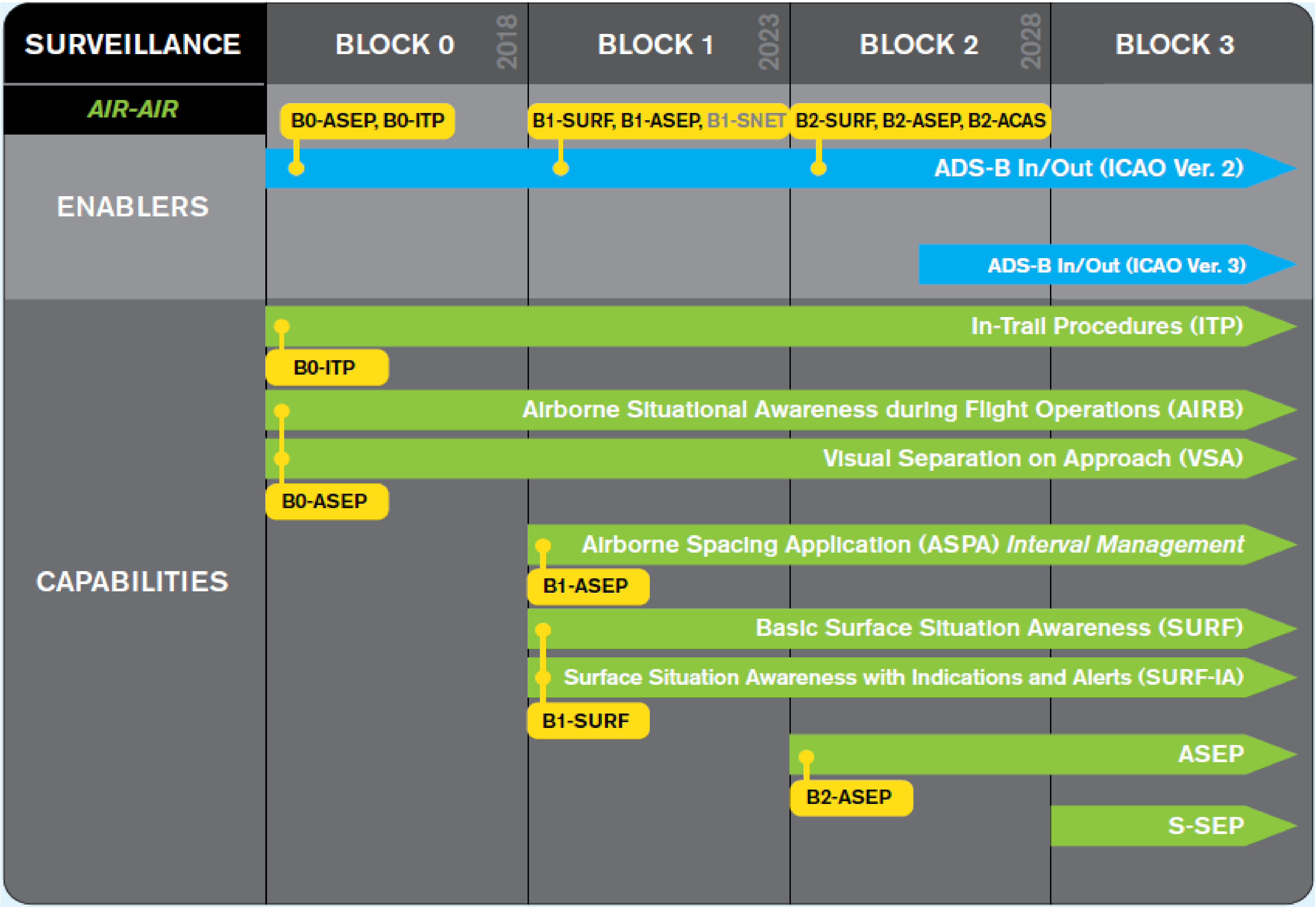
In the light of ever increasing pressure on the frequency spectrum resource as a whole, including aeronautical frequency spectrum allocations, it is imperative that civil aviation authorities and other stakeholders not only coordinate the aviation position with their State's radio regulatory authorities, but also actively participate in the WRC process.

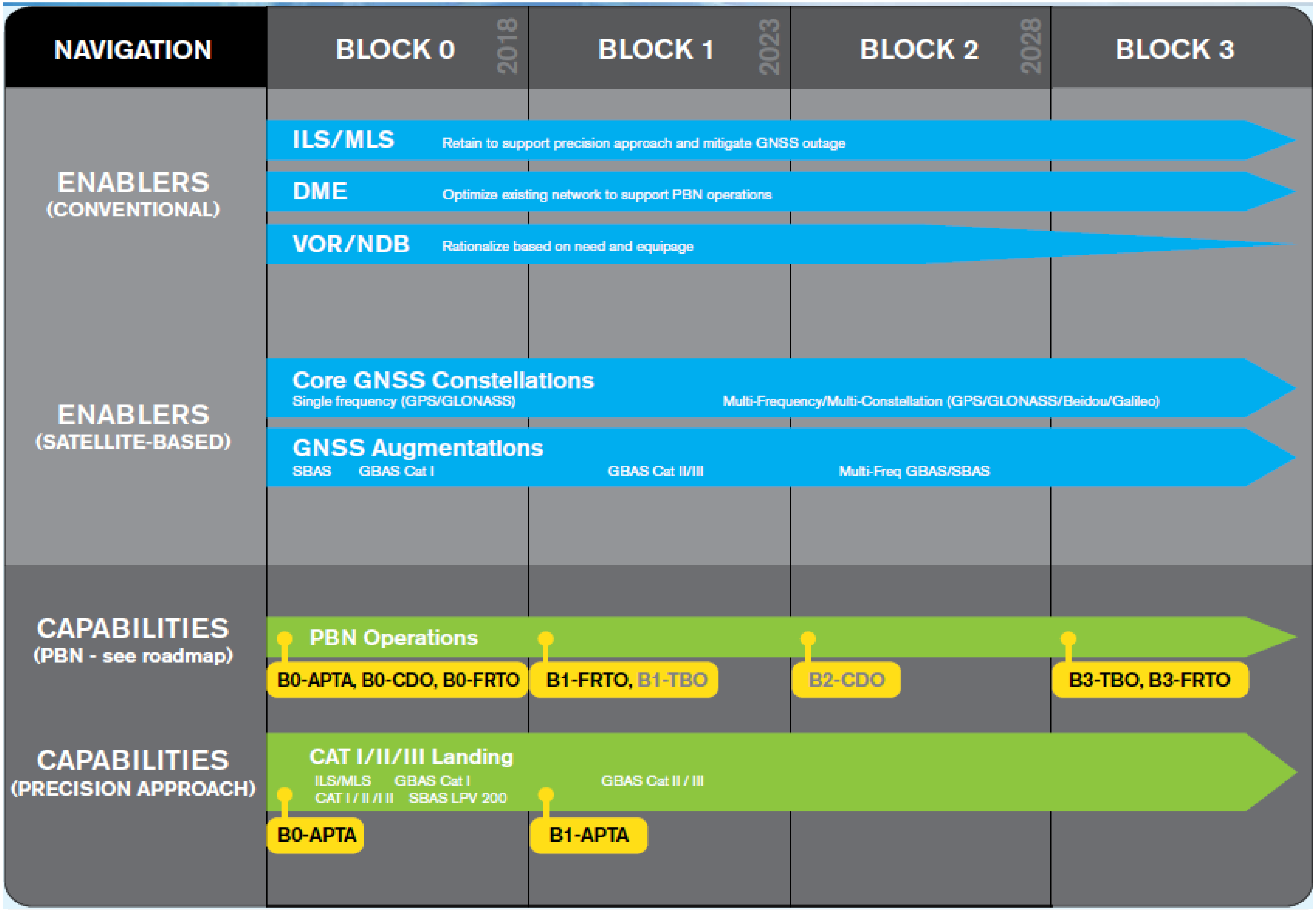
Frequency spectrum will remain a scarce and essential resource for Air Navigation as many Block Upgrades will require increased air-ground data sharing and enhanced navigation and surveillance capabilities.

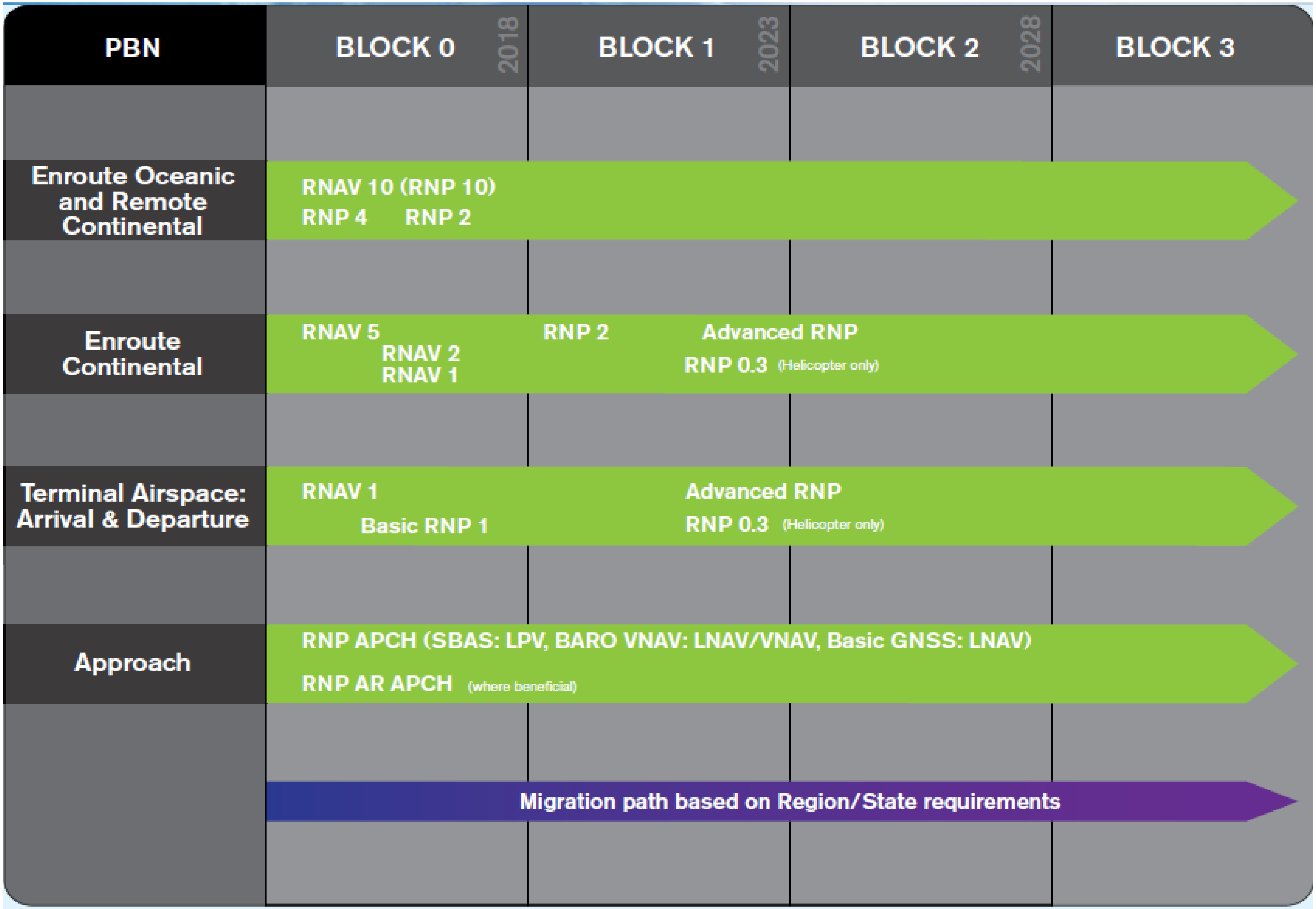

AIR-GROUND DATA COMMUNICATIONS
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
ENABLERS (LINK MEDIA)
HF (ACARS)
HF (ATN)
VDL Mode 0/A (ACARS)
B0-PFL, B0-TBO, B0-FRTO
B1-RSEQ, B1-AMET
B1-TBO, B1-ASEP, B1-FRTO
B2-SWIM
Commercial Broadband Links
VDL Mode 2
(ACARS & ATN OSI)
B2-RSEQ, B2-FICE, B2-SWIM
B2-SURF, B2-ASEP, B2-CDO
B3-FICE, B3-AMET
B3-TBO, B3-FRTO
B0-PFL, B0-TBO
B1-AMET, B1-TBO, B1-ASEP
LDACS ATN IPS
Current Satellite
Systems (ACARS)
Future
Satellite
ATN IPS
B1-RSEQ, B1-FICE
B1-AMET, B1-TBO
B2-RSEQ, B2-FICE, B2-SWIM
B2-ASEP, B2-CDO
AeroMACS ATN IPS
B2-SURF, B2-FICE, B2-SWIM
B3-FICE, B3-AMET
SERVICES
CPDLC & ADS-C over FANS/1A
ACARS
CPDLC over Baseline 1 (Link 2000+)
ATN OSI
Full 4D Applications
ATN IPS
B0-PFL, B0-TBO, B0-FRTO
Advanced CPDLC & ADS-C over Baseline 2
ATN OSI
then ATN IPS
B1-RSEQ, B1-AMET,
B1-TBO, B1-ASEP
B2-RSEQ, B2-FICE, B2-SWIM
B2-SURF, B2-ASEP, B2-CDO
B3-FICE, B3-AMET
B3-TBO
ATN OSI
then ATN IPS
Airport Surface
Datalink Services
B1-RSEQ, B1-FICE, B1-AMET
B2-SURF, B2-FICE, B2-SWIM
B3-FICE, B3-AMET

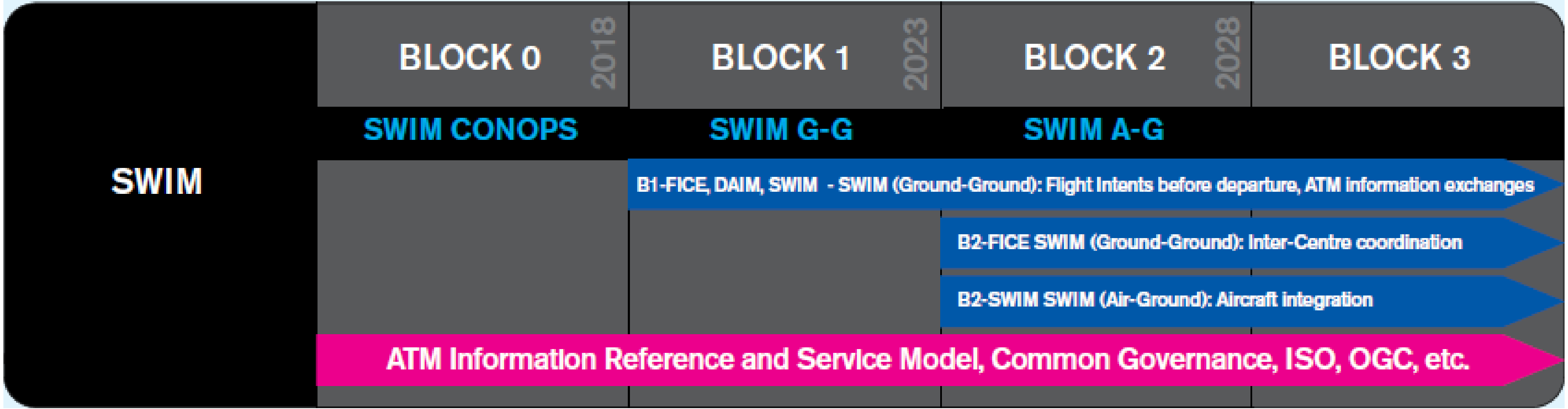

GROUND-GROUND COMMUNICATIONS
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
ENABLERS (LINK MEDIA)
B0-FICE, B0-DAIM
B1-FICE, B1-DAIM
B1-SWIM, B1-AMET
B2-FICE
B3-TBO, B3-FICE,
B3-AMET
IPV4
IPV6
IPV6 VOICE Over IP (for G/G co-ord and links to A/G txceivers)
SERVICES
B0-FICE
B1-FICE
AMHS
AIDC
Information Management
(see Roadmap)
AIR-GROUND VOICE COMMUNICATIONS
VHF (25 KHz)
VHF (8.33 KHz) CONGESTION RELIEF
ENABLERS (LINK MEDIA)
Future Digital Voice System?
HF
Current Satellite Systems
Future Satellite System

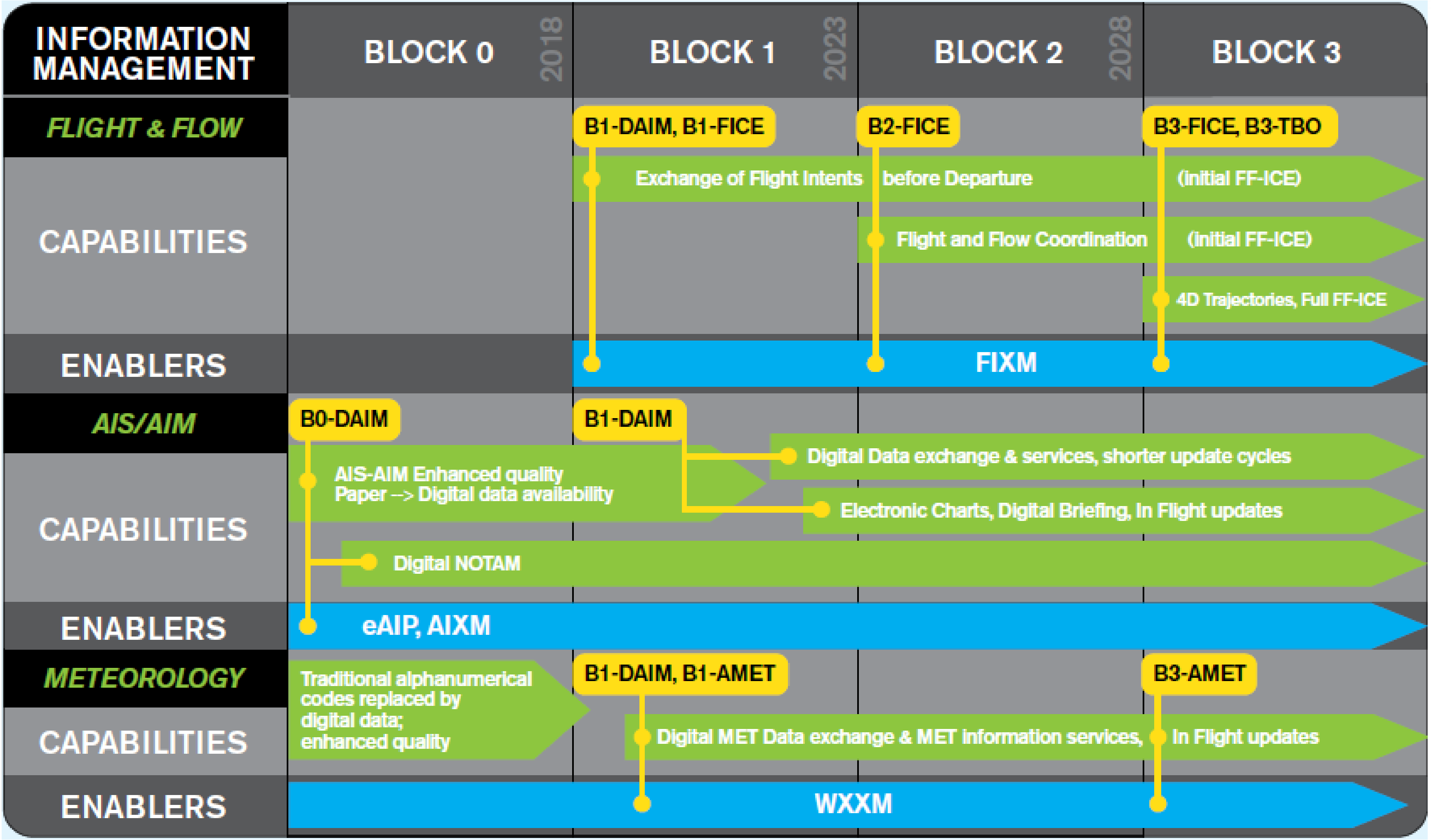

SURVEILLANCE
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
GROUND-BASED
PSR
B0-ASUR, B0-SNET
B1-SNET
MultiStatic PSR
SSR/Mode-S
ENABLERS
WAM
ADS-B In/Out (ICAO Ver. 2)
B1-TBO
Future ADS-B In/Out System
B0-TBO
ADS-B Out via Satellite
ADS-C
CAPABILITIES
B0-ASUR
Ground-based Surveillance
B0-ASUR, B0-SNET
B1-SNET
Surveillance Data Fusion
SURFACE
SMR
B0-SURF
B1-SURF, B1-RSEQ, B1-RATS
B2-SURF
ENABLERS
MLAT
ADS-B In/Out (ICAO Ver. 2)
B1-WAKE, B1-SURF, B1-RSEQ, B1-RATS
Future ADS-B In/Out System
B1-RATS
Cameras
SMGCS Level 1 and 2
CAPABILITIES
B0-SURF
B1-SURF, B1-RSEQ, B1-RATS
B2-SURF
SMGCS Level 3 and 4

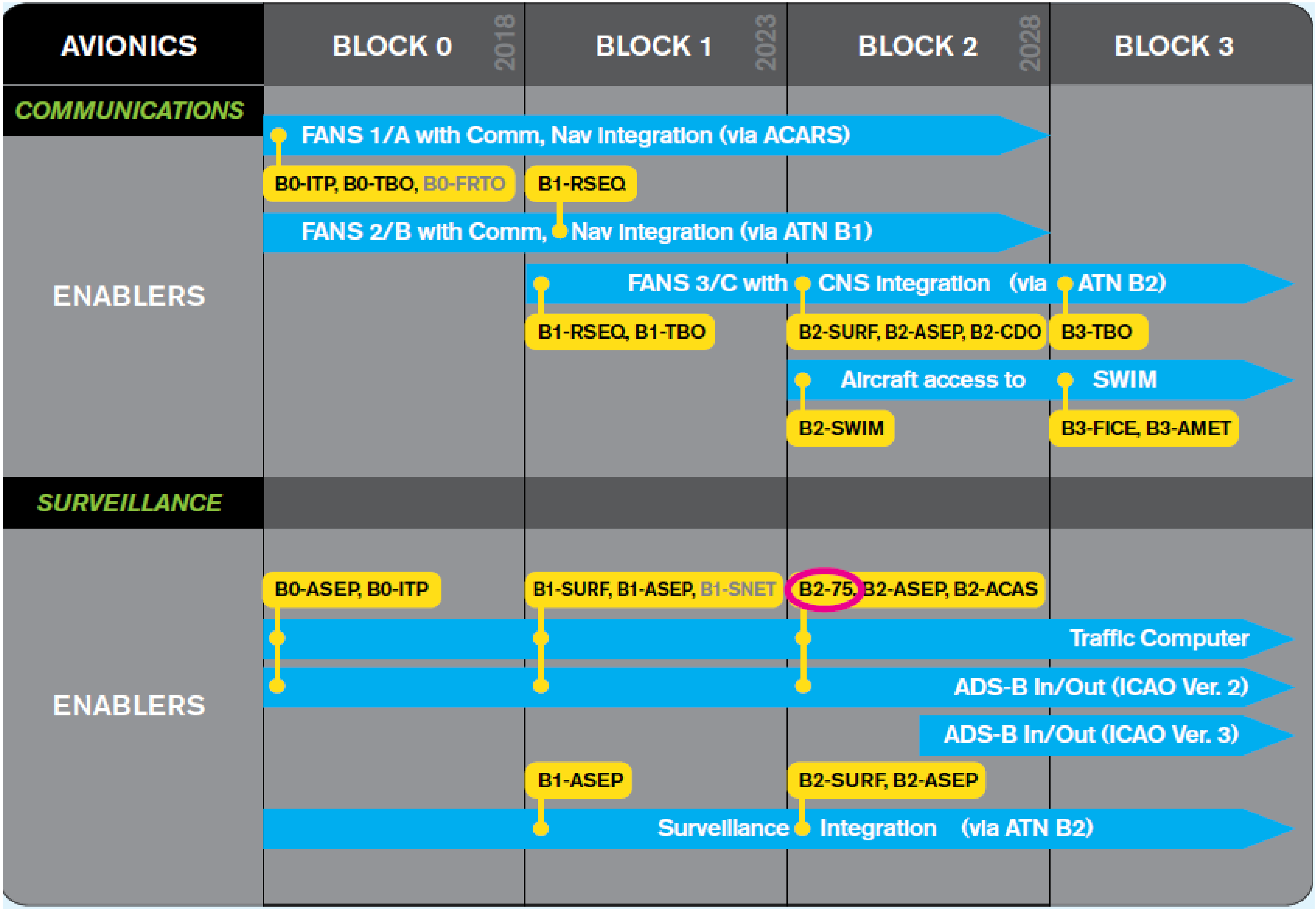

SURVEILLANCE
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
AIR-AIR
B0-ASEP, B0-ITP
B1-SURF, B1-ASEP, B1-SNET
B2-SURF, B2-ASEP, B2-ACAS
ADS-B In/Out (ICAO Ver. 2)
ENABLERS
ADS-B In/Out (ICAO Ver. 3)
In-Trail Procedures (ITP)
B0-ITP
Airborne Situational Awareness during Flight Operations (AIRB)
Visual Separation on Approach (VSA)
B0-ASEP
Airborne Spacing Application (ASPA) Interval Management
B1-ASEP
CAPABILITIES
Basic Surface Situation Awareness (SURF)
Surface Situation Awareness with Indications and Alerts (SURF-IA)
B1-SURF
ASEP
B2-ASEP
S-SEP

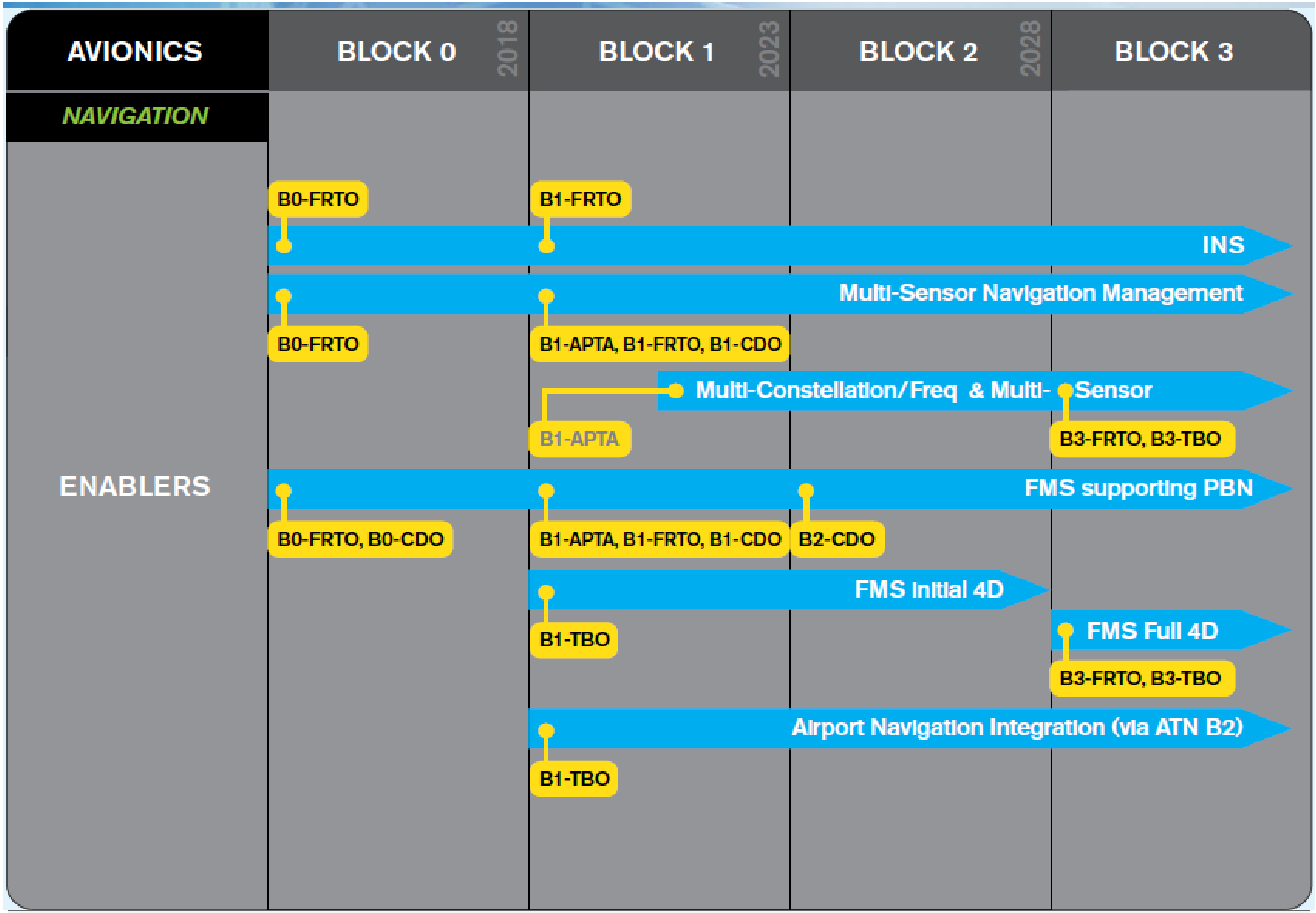

NAVIGATION
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
ENABLERS
(CONVENTIONAL)
ILS/MLS
Retain to support precision approach and mitigate GNSS outage
DME
Optimize existing network to support PBN operations
VOR/NDB
Rationalize based on need and equipage
ENABLERS
(SATELLITE-BASED)
Core GNSS Constellations
Single frequency (GPS/GLONASS)
Multi-Frequency/Multi-Constellation (GPS/GLONASS/Beidou/Galileo)
GNSS Augmentations
SBAS
GBAS Cat I
GBAS Cat II/III
Multi-Freq GBAS/SBAS
CAPABILITIES
(PBN - see roadmap)
PBN Operations
B0-APTA, B0-CDO, B0-FRTO
B1-FRTO, B1-TBO
B2-CDO
B3-TBO, B3-FRTO
CAPABILITIES
(PRECISION APPROACH)
CAT I/II/III Landing
ILS/MLS
GBAS Cat I
CAT I / II / III
SBAS LPV 200
GBAS Cat II / III
B0-APTA
B1-APTA


PBN
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
Enroute Oceanic and Remote Continental
RNAV 10 (RNP 10)
RNP 4
RNP 2
Enroute Continental
RNAV 5
RNAV 2
RNAV 1
RNP 2
Advanced RNP
RNP 0.3 (Helicopter only)
Terminal Airspace: Arrival & Departure
RNAV 1
Basic RNP 1
Advanced RNP
RNP 0.3 (Helicopter only)
Approach
RNP APCH (SBAS: LPV, BARO VNAV: LNAV/VNAV, Basic GNSS: LNAV)
RNP AR APCH (where beneficial)
Migration path based on Region/State requirements

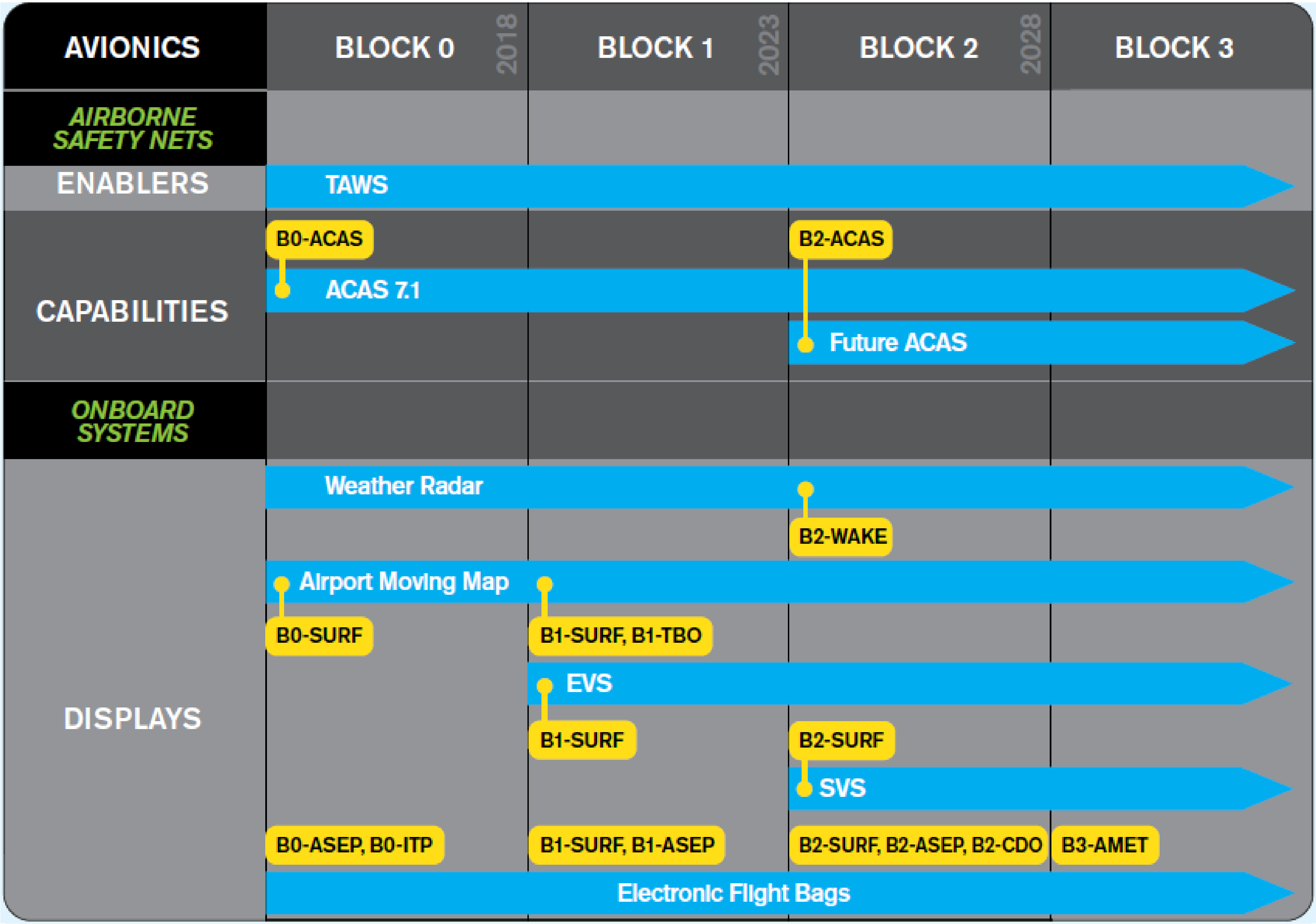

SWIM
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
SWIM CONOPS
SWIM G-G
SWIM A-G
B1-FICE, DAIM, SWIM - SWIM (Ground-Ground): Flight Intents before departure, ATM information exchanges
B2-FICE SWIM (Ground-Ground): Inter-Centre coordination
B2-SWIM SWIM (Air-Ground): Aircraft integration
ATM Information Reference and Service Model, Common Governance, ISO, OGC, etc.


INFORMATION MANAGEMENT
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
FLIGHT & FLOW
CAPABILITIES
ENABLERS
B1-DAIM, B1-FICE
B2-FICE
B3-FICE, B3-TBO
Exchange of Flight Intents before Departure
(initial FF-ICE)
Flight and Flow Coordination
(initial FF-ICE)
4D Trajectories, Full FF-ICE
FIXM
AIS/AIM
CAPABILITIES
ENABLERS
B0-DAIM
B1-DAIM
AIS-AIM Enhanced quality
Paper --> Digital data availability
Digital Data exchange & services, shorter update cycles
Electronic Charts, Digital Briefing, In Flight updates
Digital NOTAM
eAIP, AIXM
METEOROLOGY
CAPABILITIES
ENABLERS
Traditional alphanumerical codes replaced by digital data; enhanced quality
B1-DAIM, B1-AMET
B3-AMET
Digital MET Data exchange & MET information services,
In Flight updates
WXXM


AVIONICS
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
COMMUNICATIONS
ENABLERS
FANS 1/A with Comm, Nav Integration (via ACARS)
B0-ITP, B0-TBO, B0-FRTO
B1-RSEQ
FANS 2/B with Comm, Nav Integration (via ATN B1)
FANS 3/C with CNS Integration (via ATN B2)
B1-RSEQ, B1-TBO
B2-SURF, B2-ASEP, B2-CDO
B3-TBO
Aircraft access to SWIM
B2-SWIM
B3-FICE, B3-AMET
SURVEILLANCE
ENABLERS
B0-ASEP, B0-ITP
B1-SURF, B1-ASEP, B1-SNET
B2-75, B2-ASEP, B2-ACAS
Traffic Computer
ADS-B In/Out (ICAO Ver. 2)
ADS-B In/Out (ICAO Ver. 3)
B1-ASEP
B2-SURF, B2-ASEP
Surveillance Integration (via ATN B2)



AVIONICS
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
NAVIGATION
ENABLERS
B0-FRTO
B1-FRTO
INS
Multi-Sensor Navigation Management
B0-FRTO
B1-APTA, B1-FRTO, B1-CDO
Multi-Constellation/Freq & Multi- Sensor
B1-APTA
B3-FRTO, B3-TBO
FMS supporting PBN
B0-FRTO, B0-CDO
B1-APTA, B1-FRTO, B1-CDO
B2-CDO
FMS Initial 4D
B1-TBO
FMS Full 4D
B3-FRTO, B3-TBO
Airport Navigation Integration (via ATN B2)
B1-TBO


AVIONICS
BLOCK 0
2018
BLOCK 1
2023
BLOCK 2
2028
BLOCK 3
AIRBORNE SAFETY NETS
ENABLERS
TAWS
CAPABILITIES
B0-ACAS
B2-ACAS
ACAS 7.1
Future ACAS
ONBOARD SYSTEMS
DISPLAYS
Weather Radar
B2-WAKE
Airport Moving Map
B0-SURF
B1-SURF, B1-TBO
EVS
B1-SURF
B2-SURF
SVS
B0-ASEP, B0-ITP
B1-SURF, B1-ASEP
B2-SURF, B2-ASEP, B2-CDO
B3-AMET
Electronic Flight Bags

International Civil Aviation Organization
Organisation de l'aviation civile internationale
Organización de Aviación Civil Internacional
Международная организация гражданской авиации
منظمة الطيران المدني الدولي
国际民用航空组织

Tel.: +1 514-954-8219 ext. 6712

Ref.: AN 7/1.1.49-14/21

26 March 2014

Subject: Adoption of Amendment 89 to Annex 10

Action required: a) Notify any disapproval before 14 July 2014; b) Notify any differences and compliance before 13 October 2014; c) Consider the use of the Electronic Filing of Differences System (EFOD) for notification of differences and compliance

Sir/Madam,

1. I have the honour to inform you that Amendment 89 to the *International Standards and Recommended Practices, Aeronautical Telecommunications* (Annex 10 to the Convention on International Civil Aviation) was adopted by the Council at the fourth meeting of its 201st Session on 3 March 2014. Copies of the Amendment and the Resolution of Adoption are available as attachments to the electronic version of this State letter on the ICAO-NET (http://portal.icao.int) where you can access all other relevant documentation.

2. When adopting the amendment, the Council prescribed 14 July 2014 as the date on which it will become effective, except for any part concerning which a majority of Contracting States have registered their disapproval before that date. In addition, the Council resolved that Amendment 89, to the extent it becomes effective, will become applicable on 13 November 2014.

3. Amendment 89 arises from the work of the Secretariat assisted by the Navigation Systems Panel (NSP), Separation and Airspace Safety Panel (SASP), the Aeronautical Surveillance Panel (ASP) and the Operational Data Link Panel (OPLINK).

4. The amendment to Annex 10, Volume I addresses a number of issues associated with technical requirements for global navigation satellite systems (GNSS).

5. The amendment to Annex 10, Volume II addresses issues relating to automatic dependent surveillance – broadcast (ADS-B), controller-pilot data link communications (CPDLC) and in-trail procedure (ITP) to facilitate en-route climb and descent in oceanic and remote continental airspace where the lack of ATS surveillance coverage is a limiting factor.

6. The amendment to Volume IV addresses issues relating to surveillance systems.

7. In conformity with the Resolution of Adoption, may I request:

a) that before 14 July 2014 you inform me if there is any part of the adopted Standards and Recommended Practices (SARPs) amendments in Amendment 89 concerning which your Government wishes to register disapproval, using the form in Attachment B for this purpose. Please note that only statements of disapproval need be registered and if you do not reply it will be assumed that you do not disapprove of the amendment;

b) that before 13 October 2014 you inform me of the following, using the form in Attachment C for this purpose:

1) any differences that will exist on 13 November 2014 between the national regulations or practices of your Government and the provisions of the whole of Annex 10, as amended by all amendments up to and including Amendment 89, and thereafter of any further differences that may arise; and

2) the date or dates by which your Government will have complied with the provisions of the whole of Annex 10, as amended by all amendments up to and including Amendment 89.

8. With reference to the request in paragraph 7 a) above, it should be noted that a registration of disapproval of Amendment 89 or any part of it in accordance with Article 90 of the Convention does not constitute a notification of differences under Article 38 of the Convention. To comply with the latter provision, a separate statement is necessary if any differences do exist, as requested in paragraph 7 b) 1). It is recalled in this respect that international Standards in Annexes have a conditional binding force, to the extent that the State or States concerned have not notified any difference thereto under Article 38 of the Convention.

9. With reference to the request in paragraph 7 b) above, it should be also noted that the Council, at the third meeting of its 192nd Session on 4 March 2011, agreed that pending the development of a concrete policy and operational procedures governing the use of EFOD, this system be used as an alternative means for filing of differences to all Annexes, except for Annex 9 — Facilitation and Annex 17 — Security — Safeguarding International Civil Aviation against Acts of Unlawful Interference. EFOD is currently available on the USOAP restricted website (http://www.icao.int/usoap) which is accessible by all Member States (AN 1/1-11/28 refers) and you are invited to consider using this for notification of compliance and differences.

10. Guidance on the determination and reporting of differences is given in the Note on the Notification of Differences in Attachment D.

11. Please note that a detailed repetition of previously notified differences, if they continue to apply, may be avoided by stating the current validity of such differences.

12. I would appreciate it if you would also send a copy of your notifications, referred to in paragraph 7 b) above, to the ICAO Regional Office accredited to your Government.

13. As soon as practicable after the amendment becomes effective, on 14 July 2014, replacement pages incorporating Amendment 89 will be forwarded to you.

Accept, Sir/Madam, the assurances of my highest consideration.

Raymond Benjamin
Secretary General

Enclosures:

A — Amendment to the Foreword of Annex 10
B — Form on notification of disapproval of all or part of Amendment 89 to Annex 10
C — Form on notification of compliance with or differences from Annex 10
D — Note on the Notification of Differences

ATTACHMENT A to State letter AN 7/1.1.49-14/21

AMENDMENT TO THE FOREWORD OF ANNEX 10

AMENDMENT TO THE FOREWORDS OF
ANNEX 10 — *AERONAUTICAL TELECOMMUNICATIONS,*
VOLUMES I, II AND IV

VOLUME I
(Sixth Edition)

Add the following at the end of Table A:

Amendment	***Source(s)***	***Subject***	***Adopted/Approved Effective Applicable***
89	Navigation Systems Panel (NSP) Working Group of the Whole	Global navigation satellite system (GNSS)	3 March 2014 14 July 2014 13 November 2014

VOLUME II
(Sixth Edition)

Add the following at the end of Table A:

Amendment	***Source(s)***	***Subject***	***Adopted/Approved Effective Applicable***
89	Separation and Airspace Safety Panel (SASP), and Operational Data Link Panel (OPLINKP)	Automatic dependent surveillance — broadcast IN (ADS-B IN) on-board equipment, controller-pilot data link communications (CPDLC), and in trail procedure (ITP).	3 March 2014 14 July 2014 13 November 2014

VOLUME III
(Second Edition)

Add the following at the end of Table A:

Amendment	***Source(s)***	***Subject***	***Adopted/Approved Effective Applicable***
89		No change	

VOLUME IV
(Fourth Edition)

Add the following at the end of Table A:

Amendment	***Source(s)***	***Subject***	***Adopted/Approved Effective Applicable***
89	Aeronautical Surveillance Panel (ASP)	Surveillance systems	3 March 2014 14 July 2014 13 November 2014

VOLUME V
(Second Edition)

Add the following at the end of Table A:

Amendment	***Source(s)***	***Subject***	***Adopted/Approved Effective Applicable***
89		No change.	

— — — — — — — —

ATTACHMENT B to State letter AN 7/1.1.49-14/21

NOTIFICATION OF DISAPPROVAL OF ALL OR PART OF AMENDMENT 89 TO ANNEX 10

To: The Secretary General
International Civil Aviation Organization
999 University Street
Montreal, Quebec
Canada H3C 5H7

(State) ________________________________ hereby wishes to disapprove the following parts of Amendment 89 to Annex 10:

Signature ______________________________

Date ______________________________

NOTES

1) If you wish to disapprove all or part of Amendment 89 to Annex 10, please dispatch this notification of disapproval to reach ICAO Headquarters by 14 July 2014. If it has not been received by that date it will be assumed that you do not disapprove of the amendment. **If you approve of all parts of Amendment 89, it is not necessary to return this notification of disapproval.**

2) This notification should not be considered a notification of compliance with or differences from Annex 10. Separate notifications on this are necessary. (See Attachment C.)

3) Please use extra sheets as required.

— — — — — — — —

NOTIFICATION OF COMPLIANCE WITH OR DIFFERENCES FROM ANNEX 10
(Including all amendments up to and including Amendment 89)

To: The Secretary General
International Civil Aviation Organization
999 University Street
Montreal, Quebec
Canada H3C 5H7

1. No differences will exist on ________________________ between the national regulations and/or practices of **(State)** ________________________ and the provisions of Annex 10, including all amendments up to and including Amendment 89.

2. The following differences will exist on ________________________ between the regulations and/or practices of **(State)** ________________________ and the provisions of Annex 10, including Amendment 89 (Please see Note 3) below.)

a) Annex Provision	**b) Difference Category**	**c) Details of Difference**	**d) Remarks**
(Please give exact paragraph reference)	(Please indicate A, B, or C)	(Please describe the difference clearly and concisely)	(Please indicate reasons for the difference)

(Please use extra sheets as required)

3. By the dates indicated below, **(State)** ______________________________________ will have complied with the provisions of Annex 10, including all amendments up to and including Amendment 89 for which differences have been notified in 2 above.

a)	**Annex Provision** (Please give exact paragraph reference)	**b)**	**Date**	**c)**	**Comments**

(Please use extra sheets as required)

Signature ______________________________________ Date ____________________

NOTES

1) If paragraph 1 above is applicable to you, please complete paragraph 1 and return this form to ICAO Headquarters. If paragraph 2 is applicable to you, please complete paragraphs 2 and 3 and return the form to ICAO Headquarters.

2) Please dispatch the form to reach ICAO Headquarters by 13 October 2014.

3) A detailed repetition of previously notified differences, if they continue to apply, may be avoided by stating the current validity of such differences.

4) Guidance on the notification of differences from Annex 10 is provided in the Note on the Notification of Differences at Attachment D.

5) Please send a copy of this notification to the ICAO Regional Office accredited to your Government.

— — — — — — — —

ATTACHMENT D to State letter AN 7/1.1.49-14/21

NOTE ON THE NOTIFICATION OF DIFFERENCES TO ANNEX 10 AND FORM OF NOTIFICATION

(*Prepared and issued in accordance with instructions of the Council)*

1. *Introduction*

1.1 The Assembly and the Council, when reviewing the notification of differences by States in compliance with Article 38 of the Convention, have repeatedly noted that the state of such reporting is not entirely satisfactory.

1.2 With a view to achieving a more comprehensive coverage, this note is issued to facilitate the determination and reporting of such differences and to state the primary purpose of such reporting.

1.3 The primary purpose of reporting of differences is to promote safety and efficiency in air navigation by ensuring that governmental and other agencies, including operators and service providers, concerned with international civil aviation are made aware of all national regulations and practices in so far as they differ from those prescribed in the ICAO Standards.

1.4 Contracting States are, therefore, requested to give particular attention to the notification before 13 October 2014 of differences with respect to Standards in Annex 10. The Council has also urged Contracting States to extend the above considerations to Recommended Practices.

1.5 Contracting States are asked to note further that it is necessary to make an explicit statement of intent to comply where such intent exists, or where such is not the intent, of the difference or differences that will exist. This statement should be made not only to the latest amendment but to the whole Annex, including the amendment.

1.6 If previous notifications have been made in respect of this Annex, detailed repetition may be avoided, if appropriate, by stating the current validity of the earlier notification. States are requested to provide updates of the differences previously notified after each amendment, as appropriate, until the difference no longer exists.

2. *Notification of differences to Annex 10, including Amendment 89*

2.1 Past experience has indicated that the reporting of differences to Annex 10 has in some instances been too extensive since some appear merely to be a different manner of expressing the same intent.

2.2 Guidance to Contracting States in the reporting of differences to Annex 10 can only be given in very general terms. Where the national regulations of States call for compliance with procedures that are not identical but essentially similar to those contained in the Annex, no difference should be reported since the details of the procedures existing are the subject of notification through the medium of aeronautical information publications. Although differences to Recommended Practices are not notifiable under Article 38 of the Convention, Contracting States are urged to notify the Organization of the differences between their national regulations and practices and any corresponding Recommended Practices contained in an Annex. States should categorize each difference notified on the basis of whether the corresponding national regulation is:

a) ***More exacting or exceeds the ICAO Standard or Recommended Practice (SARP) (Category A)***. This category applies when the national regulation is more demanding than the corresponding SARP, or imposes an obligation within the scope of the Annex which is not covered by a SARP. This is of particular importance where a State requires a higher standard which affects the operation of aircraft of other Contracting States in and above its territory;

b) ***Different in character or other means of compliance (Category B)***[*]. This category applies when the national regulation is different in character from the corresponding ICAO SARP, or when the national regulation differs in principle, type or system from the corresponding SARP, without necessarily imposing an additional obligation; and

c) ***Less protective or partially implemented/not implemented (Category C)***. This category applies when the national regulation is less protective than the corresponding SARP; or when no national regulation has been promulgated to address the corresponding SARP, in whole or in part.

2.3 When a Contracting State deems an ICAO Standard concerning aircraft, operations, equipment, personnel, or air navigation facilities or services to be not applicable to the existing aviation activities of the State, notification of a difference is not required. For example, a Contracting State that is not a State of Design or Manufacture and that does not have any national regulations on the subject, would not be required to notify differences to Annex 8 provisions related to the design and construction of an aircraft.

2.4 For States that have already fully reported differences from Annex 10 or have reported that no differences exist, the reporting of any further differences occasioned by the amendment should be relatively straightforward; however, attention is called to paragraph 1.5 wherein it is indicated that this statement should be not only to the latest amendment but to the whole Annex, including the amendment.

3. *Form of notification of differences*

3.1 Differences should be notified in the following form:

a) *Reference*: The number of the paragraph or subparagraph in Annex 10 as amended which contains the Standard or Recommended Practice to which the difference relates;

b) *Category*: Indicate the category of the difference as A, B or C in accordance with paragraph 2.2 above;

c) *Description of the difference*: Clearly and concisely describe the difference and its effect; and

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[*] The expression "different in character or other means of compliance" in b) would be applied to a national regulation which achieves, by other means, the same objective as that of the corresponding ICAO SARPs and so cannot be classified under a) or c).

d) *Remarks*: Under "Remarks" indicate reasons for the difference and intentions including any planned date for implementation.

3.2 The differences notified will be recorded in a Supplement to the Annex, normally in the terms used by the Contracting State when making the notification. In the interest of making the supplement as useful as possible, please make statements as clear and concise as possible and confine remarks to essential points. Comments on implementation, in accordance with paragraph 4 b) 2) of the Resolution of Adoption, should not be combined with those concerning differences. The provision of extracts from national regulations cannot be considered as sufficient to satisfy the obligation to notify differences. General comments that do not relate to specific differences will not be published in Supplements.

— END —

AMENDMENT No. 89

TO THE

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
(RADIO NAVIGATION AIDS)

The amendment to Annex 10, Volume I, contained in this document was adopted by the Council of ICAO on **3 March 2014**. Such parts of this amendment as have not been disapproved by more than half of the total number of Contracting States on or before **14 July 2014** will become effective on that date and will become applicable on **13 November 2014** as specified in the Resolution of Adoption. (State letter AN 7/1.3.101-12/68 refers.)

MARCH 2014

INTERNATIONAL CIVIL AVIATION ORGANIZATION

AMENDMENT 89 TO THE INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

RESOLUTION OF ADOPTION

The Council

Acting in accordance with the Convention on International Civil Aviation, and particularly with the provisions of Articles 37, 54 and 90 thereof,

1. *Hereby adopts* on 3 March 2014 Amendment 89 to the International Standards and Recommended Practices contained in the document entitled *International Standards and Recommended Practices — Aeronautical Telecommunications, Radio Navigation Aids* which for convenience is designated Annex 10, Volume I to the Convention;

2. *Prescribes* 14 July 2014 as the date upon which the said amendment shall become effective, except for any part thereof in respect of which a majority of the Contracting States have registered their disapproval with the Council before that date;

3. *Resolves* that the said amendment or such parts thereof as have become effective shall become applicable on 13 November 2014;

4. *Requests the Secretary General*:

a) to notify each Contracting State immediately of the above action and immediately after 14 July 2014 of those parts of the amendment which have become effective;

b) to request each Contracting State:

1) to notify the Organization (in accordance with the obligation imposed by Article 38 of the Convention) of the differences that will exist on 13 November 2014 between its national regulations or practices and the provisions of the Standards in the Annex as hereby amended, such notification to be made before 13 October 2014, and thereafter to notify the Organization of any further differences that arise;

2) to notify the Organization before 13 October 2014 of the date or dates by which it will have complied with the provisions of the Standards in the Annex as hereby amended;

c) to invite each Contracting State to notify additionally any differences between its own practices and those established by the Recommended Practices, when the notification of such differences is important for the safety of air navigation, following the procedure specified in subparagraph b) above with respect to differences from Standards.

— — — — — — — —

NOTES ON THE PRESENTATION OF THE AMENDMENT TO ANNEX 10, VOLUME I

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

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

TEXT OF AMENDMENT 89 TO THE

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
(RADIO NAVIGATION AIDS)

…

CHAPTER 3. SPECIFICATIONS FOR RADIO NAVIGATION AIDS

…

3.7 Requirements for the Global Navigation Satellite System (GNSS)

…

3.7.3.1 *GPS Standard Positioning Service (SPS) (L1)*

3.7.3.1.1 *Space and control segment accuracy*

Note.— The following accuracy standards do not include atmospheric or receiver errors as described in Attachment D, 4.1.2. They apply under the conditions specified in Appendix B, 3.1.3.1.1.

3.7.3.1.1.1 *Positioning accuracy*. The GPS SPS position errors shall not exceed the following limits:

	Global average 95% of the time	Worst site 95% of the time
Horizontal position error	~~13~~9 m (~~43~~ 30 ft)	~~36~~ 17 m (~~118~~ 56 ft)
Vertical position error	~~22~~ 15 m (~~72~~ 49 ft)	~~77~~ 37 m (~~253~~ 121 ft)

3.7.3.1.1.2 *Time transfer accuracy*. The GPS SPS time transfer errors shall not exceed 40 nanoseconds 95 per cent of the time.

3.7.3.1.1.3 *Range domain accuracy*. The range domain error shall not exceed the following limits:

a) range error of any satellite — ~~the larger of:~~ 30 m (100 ft) with reliability specified in 3.7.3.1.3;

~~— 30 m (100 ft); or~~
~~— 4.42 times the broadcast user range accuracy (URA), not to exceed 150 m (490 ft);~~

b) 95th percentile range rate error of any satellite ~~— 0.02~~ 0.006 m (~~0.07~~ 0.02 ft) per second (global average);

c) 95th percentile range acceleration error of any satellite ~~— 0.007~~ 0.002 m (~~0.02~~ 0.006 ft) per second-squared (global average); and

d) ~~root-mean-square~~ 95th percentile range error ~~over all~~for any satellite~~s~~ over all time differences between time of data generation and time of use of data ~~— 6 m (20 ft)~~ 7.8 m (26 ft) (global average).

3.7.3.1.2 *Availability*. The GPS SPS availability shall be as follows:

≥99 per cent horizontal service availability, average location (~~36~~ 17 m 95 per cent threshold)

≥99 per cent vertical service availability, average location (~~77~~ 37 m 95 per cent threshold)

≥90 per cent horizontal service availability, worst-case location (~~36~~ 17 m 95 per cent threshold)

≥90 per cent vertical service availability, worst-case location (~~77~~ 37 m 95 per cent threshold)

3.7.3.1.3 *Reliability*. The GPS SPS reliability shall be within the following limits:

~~a) frequency of a major service failure — not more than three per year for the constellation (global average);~~

~~b~~a) reliability — at least 99.94 per cent (global average); and

~~c~~b) reliability — at least 99.79 per cent (worst single point average).

3.7.3.1.4 *Probability of major service failure.* The probability that the user range error (URE) of any satellite will exceed 4.42 times the upper bound on the user range accuracy (URA) broadcast by that satellite without an alert received at the user receiver antenna within 10 seconds shall not exceed 1×10^{-5} per hour.

Note.— The different alert indications are described in U.S. Department of Defense, "Global Positioning System – Standard Positioning Service – Performance Standard", 4th Edition, September 2008, Section 2.3.4.

3.7.3.1.5 *Continuity*. The probability of losing GPS SPS signal-in-space (SIS) availability from a slot of the nominal 24-slot constellation due to unscheduled interruption shall not exceed 2×10^{-4} per hour.

3.7.3.1.46 *Coverage.* The GPS SPS shall cover the surface of the earth up to an altitude of 3 000 kilometres.

Note.— Guidance material on GPS accuracy, availability, reliability and coverage is given in Attachment D, 4.1.

Renumber paragraphs 3.7.3.1.5 – 3.7.3.1.8

…

APPENDIX B. TECHNICAL SPECIFICATIONS FOR THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

…

3.1.3.1 *GNSS (GPS) RECEIVER*

3.1.3.1.1 *Satellite exclusion*. The receiver shall exclude any ~~satellite designated~~ marginal or unhealthy satellite ~~by the GPS satellite ephemeris health flag~~.

Note.— Conditions indicating that a satellite is "healthy", "marginal" or "unhealthy" can be found in U.S. Department of Defense, "Global Positioning System – Standard Positioning Service – Performance Standard"*, 4th Edition, September 2008, Section 2.3.2.*

...

3.5.7.1 *GENERAL*

…

3.5.7.1.3 *"Do Not Use"*. SBAS shall broadcast a "Do Not Use" message (Type 0 message) when necessary to inform users not to use the SBAS satellite ranging function and its broadcast data.

3.5.7.1.4 The Doppler shift in the GEO satellite signal seen at any fixed location within the GEO footprint for any GEO shall not exceed ±450 Hz.

Note .— This maximum Doppler shift corresponds approximately to the maximum GEO satellite orbit inclination that can be supported by the coding ranges for Type 9 and Type 17 messages.

3.5.7.1.5 *Geostationary orbit (GEO) ranging function parameters.* Each SBAS satellite shall broadcast geostationary orbit (GEO) ranging function parameters (defined in 3.5.4.2).

Note — It is necessary to broadcast geostationary orbit ranging function parameters even when a ranging function is not provided, so that airborne receivers may implement a positive identification of the broadcasting SBAS satellite. When ranging is not provided, the accuracy of the Type 17 data (and Type 9 data) only needs to support the acquisition of the satellite.

3.5.7.1.5.1 The error in the Doppler shift of a GEO satellite derived from any Type 9 message that has not timed out, with respect to the true GEO Doppler shift seen at any fixed location within the GEO footprint, shall not exceed ±210 Hz.

3.5.7.1.~~4~~6 *Almanac data*. Each SBAS satellite shall broadcast almanac data ~~for SBAS satellites~~ (defined in 3.5.4.3) for all SBAS satellites of the same service provider. ~~with error less than 150 km (81 NM) of the true satellite position. Unused almanac slots in Type 17 messages shall be coded with a PRN code number of "0". The health and status shall indicate satellite status and the service provider as defined in 3.5.4.3.~~

3.5.7.1.6.1 The error in the estimated position of the satellite derived from any Type 17 message broadcast within the previous 15 minutes, with respect to the true satellite position, shall not exceed 3,000 km.

3.5.7.1.6.2 The separation distance between the estimated position of the satellite derived from any Type 17 message broadcast within the previous 15 minutes and the position of the satellite derived from the GEO ranging parameters in any Type 9 message that has not timed out shall not exceed 200 km.

3.5.7.1.6.3 The error in the Doppler shift of a GEO satellite derived from any Type 17 message broadcast within the previous 15 minutes, with respect to the true GEO Doppler shift seen at any fixed location within the GEO footprint, shall not exceed ±210 Hz.

3.5.7.1.6.4 SBAS shall not broadcast almanac data for any SBAS satellite from a different service provider for which the position estimated from the almanac data broadcast within the previous 15 minutes would be within 200 km of the position of any of its own GEOs as derived from the GEO ranging parameters from any Type 9 message that has not timed out.

3.5.7.1.6.5 Where the estimated position of a GEO satellite providing a ranging function, derived from the Type 17 message broadcast within the previous 15 minutes, is within 200 km of the position of another GEO satellite of the same service provider, derived from a Type 9 message for this GEO that has not timed out, the GEO UDRE value shall be set sufficiently large to account for the possibility that a user could misidentify the PRN of the GEO providing the ranging function.

3.5.7.1.6.6 The health and status parameter shall indicate the satellite status and the service provider identifier, as defined in 3.5.4.3.

3.5.7.1.6.7 Unused almanac slots in Type 17 messages shall be coded with a PRN code number of "0".

3.5.7.1.6.8 The service provider shall ensure the correctness of the service provider ID broadcast in any almanac.

~~3.5.7.1.5 **Recommendation.—** *SBAS should broadcast almanac data for all SBAS satellites, regardless of the service provider.*~~

…

Table B-54. Data broadcast intervals and supported functions

Data type	Maximum broadcast interval	Ranging	GNSS satellite status	Basic differential correction	Precise differential correction	Associated message types
…						
GEO ranging function data	120 s	R	R	R	R	9
…						

Notes.—
1. "R" indicates that the data must be broadcast to support the function.
…

…

3.5.7.3 *GNSS satellite status function*. If an SBAS provides a satellite status function, it shall also comply with the requirements contained in this section.

Note — An SBAS may be able to provide integrity on some GPS satellites that are designated either marginal or unhealthy.

…

3.5.8.1 *SBAS-capable GNSS receiver*. Except as specifically noted, the SBAS-capable GNSS receiver shall process the signals of the SBAS and meet the requirements specified in 3.1.3.1 (GPS receiver) and/or 3.2.3.1 (GLONASS receiver). Pseudo-range measurements for each satellite shall be smoothed using carrier measurements and a smoothing filter which deviates less than 0.1 metre within 200 seconds after initialization, relative to the steady-state response of the filter defined in 3.6.5.1 in the presence of drift between the code phase and integrated carrier phase of up to 0.01 metre per second.

3.5.8.1.1 *GEO satellite acquisition*. The receiver shall be able to acquire and track GEO satellites for which a stationary receiver at the user receiver location would experience a Doppler shift as large as ±450 Hz.

3.5.8.1.~~1~~2 *Conditions for use of data*. The receiver shall use data from an SBAS message only if the CRC of this message has been verified. Reception of a Type 0 message from an SBAS satellite shall result in deselection of that satellite and all data from that satellite shall be discarded for at least 1 minute. For GPS satellites, the receiver shall apply long-term corrections only if the IOD matches both the IODE and 8 least significant bits of the IODC. For GLONASS satellites, the receiver shall apply long-term corrections only if the time of reception (t_r) of the GLONASS ephemeris is inside the following IOD validity interval, as defined in 3.5.4.4.1:

$$t_{LT} - L - V \le t_r \le t_{LT} - L$$

Note 1.— For SBAS satellites, there is no mechanism that links GEO ranging function data (Type 9 message) and long-term corrections.

Note 2.— This requirement does not imply that the receiver has to stop tracking the SBAS satellite.

3.5.8.1.2.1 *SBAS satellite identification*. Upon acquisition or re-acquisition of an SBAS satellite, the receiver shall not use SBAS satellite data unless the calculated separation between the satellite position derived from its GEO ranging function parameters and the satellite position derived from the almanac message most recently received from the same service provider within the last 15 minutes is less than 200 km.

Note. — This check ensures that a receiver will not mistake one SBAS satellite for another due to cross-correlation during acquisition or re-acquisition.

Renumber paragraphs 3.5.8.1.1.1 – 3.5.8.1.1.11

…

3.5.8.2.4 *Almanac data*

3.5.8.2.4.1 **Recommendation.—** *The almanac data provided by the SBAS should be used for acquisition.*

Note.— Health and status information ~~is~~ provided in the GEO almanac data ~~to support acquisition, but need not be used as a condition for use of that satellite~~ does not override or invalidate data provided in other SBAS messages. The use of bits 0 to 2 by airborne equipment is optional; there are no requirements covering their usage.

…

3.5.8.3 *GNSS satellite status function*. The receiver shall exclude satellites from the position solution if they are identified as “Do Not Use” by SBAS. If SBAS-provided integrity is used, the receiver shall not be required to exclude GPS satellites based on the GPS-provided ephemeris health flag as required in 3.1.3.1.1 or to exclude GLONASS satellites based on GLONASS-provided ephemeris health flag as required in 3.2.3.1.1.

Note 1.— In the case of a satellite designated marginal or unhealthy by the core satellite constellation(s) health flag, SBAS may be able to broadcast ephemeris and clock corrections that will allow the user to continue using the satellite.

…

3.5.8.4.2 *Precision approach and APV operations*

…

3.5.8.4.2.5 The parameters that define the approach path for a single precision approach or APV shall be contained in the FAS data block.

Note 1.— The FAS path is a line in space defined by the landing threshold point/fictitious threshold point (LTP/FTP), flight path alignment point (FPAP), threshold crossing height (TCH) and glide path angle (GPA). The local level plane for the approach is a plane perpendicular to the local vertical passing through the LTP/FTP (i.e. tangent to the ellipsoid at the LTP/FTP). Local vertical for the approach is normal to the WGS-84 ellipsoid at the LTP/FTP. The glide path intercept point (GPIP) is where the final approach path intercepts the local level plane.

Note 2.— For SBAS, FAS data blocks are stored in airborne databases. The format of the data for validation of a cyclic redundancy check is shown in Attachment D, 6.6. It differs from the GBAS FAS data block in 3.6.4.5.

…

3.5.8.4.2.5.1 FAS data block parameters shall be as follows (see Table B-57A):

Operation type: straight-in approach procedure or other operation types.

Coding: 0 = straight-in approach procedure
1 to 15 = spare

SBAS service provider ID: indicates the service provider associated with this FAS data block.

Coding: See Table B-27.
14 = FAS data block is to be used with GBAS only.
15 = FAS data block can be used with any SBAS service provider.

Airport ID: the three- or four-letter designator used to designate an airport.

Coding: Each character is coded using the lower 6 bits of its IA-5 representation. For each character, b_1 is transmitted first, and 2 zero bits are appended after b_6, so that 8 bits are transmitted for each character. Only upper case letters, numeric digits and IA-5 “space” are used. The rightmost character is transmitted first. For a three-character airport ID, the rightmost (first transmitted) character shall be IA-5 “space”.

Runway number: the runway orientation, point in space final approach course, or SBAS circling only procedure course rounded to the nearest 10 degrees and truncated to two characters.

Coding: 01 to 36 = runway number

Note.— For heliport operations, the runway number value is the integer nearest to one tenth of the final approach course, except when that integer is zero, in which case the runway number is 36.

Runway letter: the one-letter designator used, as necessary, to differentiate between parallel runways.

Coding: 0 = no letter
1 = R (right)
2 = C (centre)
3 = L (left)

Approach performance designator: this field is not used by SBAS.

Table B-57A. Final approach segment (FAS) data block

Data content	Bits used	Range of values	Resolution
Operation type	4	0 to 15	1
SBAS provider ID	4	0 to 15	1
Airport ID	32	—	—
Runway number	6	01 to 36	1
Runway letter	2	—	—
Approach performance designator	3	0 to 7	1
Route indicator	5	—	—
Reference path data selector	8	0 to 48	1
Reference path identifier	32	—	—
LTP/FTP latitude	32	±90.0°	0.0005 arcsec
LTP/FTP longitude	32	±180.0°	0.0005 arcsec
LTP/FTP height	16	–512.0 to 6 041.5 m	0.1 m
ΔFPAP latitude	24	±1.0°	0.0005 arcsec
ΔFPAP longitude	24	±1.0°	0.0005 arcsec
Approach TCH (Note 1)	15	0 to 1 638.35 m or 0 to 3 276.7 ft	0.05 m or 0.1 ft
Approach TCH units selector	1	—	—
GPA	16	0 to 90.0°	0.01°
Course width	8	80 to 143.75 m	0.25 m
ΔLength offset	8	0 to 2 032 m	8 m
Horizontal alert limit (HAL)	8	0 to 51.0 m	0.2 m
Vertical alert limit (VAL) (Note 2)	8	0 to 51.0 m	0.2 m
Final approach segment CRC	32		—

Note 1.— Information can be provided in either feet or metres as indicated by the approach TCH unit selector.

Note 2.— A VAL of 0 indicates that the vertical deviations cannot be used (i.e., a lateral only approach). This does not preclude providing advisory vertical guidance on such approaches, refer to FAA AC 20-138().

Route indicator: a “blank” or the one-letter identifier used to differentiate between multiple procedures to the same runway end.

Note.— Procedures are considered to be different even if they only differ by the missed approach segment.

Coding: The letter is coded using bits b_1 through b_5 of its IA-5 representation. Bit b_1 is transmitted first. Only upper case letters, excluding “I” and “O”, or IA-5 “space” (blank) are used. Blank indicates that there is only one procedure to the runway end. For multiple procedures to the same runway end the route indicator is coded using a letter starting from Z and moving backward in the alphabet for additional procedures.

Reference path data selector (RPDS): this field is not used by SBAS.

Reference path identifier (RPI): four characters used to uniquely designate the reference path. The four characters consist of three alphanumeric characters plus a blank or four alphanumeric characters.

Note.— The best industry practice matches the 2nd and 3rd character encoding to the encoded runway number. The last character is a letter starting from A or a “blank.”

Coding: Each character is coded using bits b_1 through b_6 of its IA-5 representation. For each character, b_1 is transmitted first, and 2 zero bits are appended after b_6 so that 8 bits are transmitted for each character. Only upper case letters, numeric digits and IA-5 “space” are used. The rightmost character is transmitted first. For a three-character reference path identifier, the rightmost (first transmitted) character shall be IA-5 “space”.

Note.— The LTP/FTP is a point over which the FAS path passes at a height above the LTP/FTP height specified by the TCH.

LTP/FTP latitude: the latitude of the LTP/FTP point in arc seconds.

Coding: positive value denotes north latitude.
negative value denotes south latitude.

LTP/FTP longitude: the longitude of the LTP/FTP point in arc seconds.

Coding: positive value denotes east longitude.
negative value denotes west longitude.

LTP/FTP height: the height of the LTP/FTP above the WGS-84 ellipsoid.

Coding: This field is coded as an unsigned fixed-point number with an offset of –512 metres. A value of zero in this field places the LTP/FTP 512 metres below the earth ellipsoid.

Note.— The FPAP is a point at the same height as the LTP/FTP that is used to define the alignment of the approach. The origin of angular deviations in the lateral direction is defined to be 305 metres (1 000 ft) beyond the FPAP along the lateral FAS path. For an approach aligned with the runway, the FPAP is at or beyond the stop end of the runway.

ΔFPAP latitude: the difference of latitude of the runway FPAP from the LTP/FTP in arc seconds.

Coding: Positive value denotes the FPAP latitude north of LTP/FTP latitude.

Negative value denotes the FPAP latitude south of the LTP/FTP latitude.

ΔFPAP longitude: the difference of longitude of the runway FPAP from the LTP/FTP in arc seconds.

Coding: Positive value indicates the FPAP longitude east of LTP/FTP longitude.
Negative value indicates the FPAP longitude west of LTP/FTP longitude.

Approach TCH: the height of the FAS path above the LTP/FTP defined in either feet or metres as indicated by the TCH units selector.

Approach TCH units selector: the units used to describe the TCH.

Coding: 0 = feet
1 = metres

Glide path angle (GPA): the angle of the FAS path with respect to the horizontal plane tangent to the WGS-84 ellipsoid at the LTP/FTP.

Course width: the lateral displacement from the path defined by the FAS at the LTP/FTP at which full-scale deflection of a course deviation indicator is attained.

Coding: This field is coded as an unsigned fixed-point number with an offset of 80 metres. A value of zero in this field indicates a course width of 80 metres at the LTP/FTP.

ΔLength offset: the distance from the stop end of the runway to the FPAP.

Coding: 1111 1111 = not provided

HAL: Horizontal alert limit to be used during the approach in meters.

VAL: Vertical alert limit to be used during the approach in meters.

Final approach segment CRC: the 32-bit CRC appended to the end of each FAS data block in order to ensure approach data integrity. The 32-bit final approach segment CRC shall be calculated in accordance with 3.9. The length of the CRC code shall be k = 32 bits.

The CRC generator polynomial shall be:

$$G(x) = x^{32} + x^{31} + x^{24} + x^{22} + x^{16} + x^{14} + x^{8} + x^{7} + x^{5} + x^{3} + x + 1$$

The CRC information field, M(x), shall be:

$$M(x) = \sum_{i=1}^{288} m_i x^{288-i} = m_1 x^{287} + m_2 x^{286} + \ldots + m_{288} x^0$$

M(x) shall be formed from all bits of the associated FAS data block, excluding the CRC. Bits shall be arranged in the order transmitted, such that m_1 corresponds to the LSB of the operation type field, and m_{288} corresponds to the MSB of the Vertical Alert Limit (VAL) field. The CRC shall be ordered such that r_1 is the LSB and r_{32} is the MSB.

3.5.8.4.2.5.2 For precision approach and APV operations, the service provider ID broadcast Type 17 message shall be identical to the service provider ID in the FAS data block, except if ID equals 15 in the FAS data block.

Note.— ~~*For SBAS, FAS data blocks are stored in airborne databases. The format of the data for validation of a cyclic redundancy check is shown in Attachment D, 6.6. It differs from the GBAS FAS data block in 3.6.4.5 in that it contains the SBAS HAL and VAL for the particular approach procedure. For approaches conducted using SBAS pseudo-range corrections, the service provider ID in the FAS data block is the same as the service provider ID broadcast as part of the health and status information in Type 17 message.*~~ *If the service provider ID in the FAS data block equals 15, then any service provider can be used. If the service provider ID in the FAS data block equals 14, then SBAS precise differential corrections cannot be used for the approach.*

3.5.8.4.2.5.3 *SBAS FAS data points accuracy.* The survey error of all the FAS data points, relative to WGS-84, shall be less than 0.25 metres vertical and 1 metre horizontal.

…

3.6.4.5.1 *FAS data block.*

…

The CRC information field, M(x), shall be:

$$M(x)=\sum_{i=1}^{272} m_i\, x^{272-i} \cancel{+} = m_1 x^{271} + m_2 x^{\cancel{272}\,270} + \ldots + m_{272} x^0$$

…

3.6.7.2.4 *Final approach segment data*

3.6.7.2.4.1 *FAS data points accuracy*. The relative survey error between the FAS data points and the GBAS reference point shall be less than 0.25 metres vertical and 0.40 metres horizontal.

~~3.6.7.2.4.2 *SBAS FAS data points accuracy.* For use with SBAS, the survey error of all the FAS data points, relative to WGS-84, shall be less than 0.25 metres vertical and 1 metre horizontal.~~

3.6.7.2.4.~~3~~2 **Recommendation.—** *The final approach segment CRC should be assigned at the time of procedure design, and kept as an integral part of the FAS data block from that time onward.*

3.6.7.2.4.~~4~~3 **Recommendation.—** *The GBAS should allow the capability to set the FASVAL and FASLAL for any FAS data block to "1111 1111" to limit the approach to lateral only or to indicate that the approach must not be used, respectively.*

…

ATTACHMENT D. INFORMATION AND MATERIAL FOR GUIDANCE IN THE APPLICATION OF THE GNSS STANDARDS AND RECOMMENDED PRACTICES

3. Navigation system performance requirements

3.4 Continuity of service

…

3.4.3.4 For those areas where the system design does not meet the average continuity risk specified in the SARPs, it is still possible to publish procedures. However, specific operational mitigations should be put in place to cope with the reduced continuity expected. For example, flight planning may not be authorized based solely on a GNSS navigation means with such a high average continuity risk.

…

4. GNSS core elements

4.1 GPS

Note.— Additional information concerning GPS can be found in the Global Positioning System Standard Positioning Service — Performance Standard*, ~~October 2001~~September 2008, and Interface ~~Control Document~~ Specification (I~~CD~~S)-GPS-200~~C~~E.*

4.1.1 The performance standard is based upon the assumption that a representative standard positioning service (SPS) receiver is used. A representative receiver has the following characteristics:

a) designed in accordance with ~~ICD~~IS-GPS-200~~C~~E;
b) uses a 5-degree masking angle;
c) accomplishes satellite position and geometric range computations in the most current realization of the World Geodetic System 1984 (WGS-84) Earth-Centred, Earth-Fixed (ECEF) coordinate system;
d) generates a position and time solution from data broadcast by all satellites in view;
e) compensates for dynamic Doppler shift effects on nominal SPS ranging signal carrier phase and C/A code measurements;
f) excludes ~~GPS~~ marginal and unhealthy satellites from the position solution;
g) uses up-to-date and internally consistent ephemeris and clock data for all satellites it is using in its position solution; and
h) loses track in the event that a GPS satellite stops transmitting a trackable signal.

The time transfer accuracy applies to ~~a stationary receiver operating at a surveyed location~~the data in the broadcast navigation message, which relates GPS SPS time to UTC as maintained by the United States Naval Observatory. A 12-channel receiver will meet performance requirements specified in Chapter 3, 3.7.3.1.1.1 and 3.7.3.1.2. A receiver that is able to track four satellites only (Appendix B, 3.1.3.1.2) will not get the full accuracy and availability performance.

Note.— Conditions indicating that a satellite is "healthy", "marginal" or "unhealthy" can be found in U.S. Department of Defense, "Global Positioning System – Standard Positioning Service – Performance Standard"*, 4th Edition, September 2008, Section 2.3.2.*

4.1.2 *Position domain ~~A~~accuracy*. The position domain accuracy is measured with a representative receiver and a measurement interval of 24 hours for any point within the coverage area. The positioning and timing accuracy are for the signal-in-space (SIS) only and do not include such error sources as: ionosphere, troposphere, interference, receiver noise or multipath. ~~The accuracy is derived based on the worst two of 24 satellites being removed from the constellation and a 6-metre constellation RMS SIS user range error (URE).~~

4.1.3 *Range domain accuracy*. The range domain accuracy standard applies to normal operations, which implies that updated navigation data is uplinked to the satellites on regular basis. Range domain accuracy is conditioned by the satellite indicating a healthy status and transmitting C/A code and does not account for satellite failures outside of the normal operating characteristics. Range domain accuracy limits can be exceeded during satellite failures or anomalies while uploading data to the satellite. ~~Exceedance of the range error limit constitutes a major service failure as described in 4.1.6.~~ The range rate error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The range acceleration error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. ~~The root-mean-square range error accuracy is the average of the RMS URE of all satellites over any 24-hour interval for any point within the coverage area.~~ Under nominal conditions, all satellites are maintained to the same standards, so it is appropriate for availability modelling purposes to assume that all satellites have a ~~6~~4-metre RMS SIS user range error (URE). The standards are restricted to range domain errors allocated to space and control segments.

4.1.4 *Availability*. The availability standard applies to normal operations, which implies that updated navigation data is uplinked to the satellites on regular basis. Availability is the percentage of time over any 24-hour interval that the predicted 95 per cent positioning error (due to space and control segment errors) is less than its threshold, for any point within the coverage area. It is based on a ~~36~~17-metre horizontal 95 per cent threshold; a ~~77~~37-metre vertical 95 per cent threshold; using a representative receiver; and operating within the coverage area over any 24-hour interval. The service availability assumes ~~the worst combination of two satellites out of service~~a constellation that meets the criteria in 4.1.4.2.

4.1.4.1 *Relationship to augmentation availability.* The availability of ABAS, GBAS and SBAS does not directly relate to the GPS availability defined in Chapter 3, 3.7.3.1.2. States and operators must evaluate the availability of the augmented system by comparing the augmented performance to the requirements. Availability analysis is based on an assumed satellite constellation and the probability of having a given number of satellites.

4.1.4.2 *Satellite/constellation availability.* Twenty-four operational satellites ~~are available~~ will be maintained on orbit with 0.95 probability (averaged over any day), where a satellite is defined to be operational if it is capable of, but is not necessarily transmitting, a usable ranging signal. At least 21 satellites in the ~~24~~ nominal 24 ~~plane/~~slot positions must be set healthy and must be transmitting a navigation signal with 0.98 probability (~~yearly averaged~~normalized annually). At least 20 satellites in the nominal 24 slot positions must be set healthy and must be transmitting a navigation signal with 0.99999 probability (normalized annually).

4.1.5 *Reliability*. Reliability is the percentage of time over a specified time interval that the instantaneous SPS SIS URE is maintained within the range error limit, at any given point within the coverage area, for all healthy GPS satellites. The reliability standard is based on a measurement interval of one year and the average of daily values within the coverage area. The worst single point average reliability assumes that the total service failure time of 18 hours will be over that particular point (3 failures each lasting 6 hours).

4.1.6 *Major service failure.* A major service failure is defined to be a condition over a time interval during which a healthy GPS satellite's ranging signal error (excluding atmospheric and receiver errors) exceeds the range error limit of 4.42 times the upper bound on the user range accuracy (URA) broadcast by a satellite for longer than the allowable time to alert (10 seconds). ~~As defined in Chapter 3, 3.7.3.1.1.3 a), the range error limit is the larger of:~~

~~a) 30 m; or~~

~~b) 4.42 times the URA, not to exceed 150 m.~~ The probability of 1×10^{-5} in Chapter 3, 3.7.3.1.4 corresponds to a maximum of 3 major service failures for the entire constellation per year assuming a maximum constellation of 32 satellites.

4.1.7 *Continuity.* Continuity for a healthy GPS satellite is the probability that the SPS SIS will continue to be healthy without unscheduled interruption over a specified time interval. Scheduled interruptions which are announced at least 48 hours in advance do not contribute to a loss of continuity.

4.1.~~7~~8 *Coverage*. The SPS supports the terrestrial coverage area, which is from the surface of the earth up to an altitude of 3 000 km.

…

6.6 SBAS final approach segment (FAS) data block

6.6.1 The SBAS final approach segment (FAS) data block for a particular approach procedure is as shown in ~~Table D-1~~ Appendix B, 3.5.8.4.2.5.1 and Table B-57A. It is the same as the GBAS FAS data block defined in Appendix B, section 3.6.4.5.1 and Table B-66, with the following exceptions. ~~that t~~The SBAS FAS data block also contains the HAL and VAL to be used for the approach procedure as described in 6.3.4. SBAS user equipment interprets certain fields differently from GBAS user equipment

6.6.2 FAS data blocks for SBAS and some GBAS approaches are held within a common on-board database supporting both SBAS and GBAS. Within this database, channel assignments must be unique for each approach and coordinated with civil authorities. States are responsible for providing the FAS data for incorporation into the database. ~~The FAS block for a particular approach procedure is described in Appendix B, 3.6.4.5.1 and Table B-66.~~

6.6.3 An example of the coding of FAS data block for SBAS is provided in Table D-1. This example illustrates the coding of the various application parameters, including the cyclic redundancy check (CRC). The engineering values for the message parameters in the table illustrate the message coding process.

Table D-1. Example of an SBAS FAS data block

~~Data content~~	~~Bits used~~	~~Range of values~~	~~Resolution~~
~~Operation type~~	4	~~0 to 15~~	~~1~~
~~SBAS provider ID~~	4	~~0 to 15~~	~~1~~
~~Airport ID~~	~~32~~	–	–
~~Runway number~~	~~6~~	~~1 to 36~~	~~1~~
~~Runway letter~~	~~2~~	–	–
~~Approach performance designator~~	~~3~~	~~0 to 7~~	~~1~~
~~Route indicator~~	~~5~~	–	–
~~Reference path data selector~~	~~8~~	~~0 to 48~~	~~1~~
~~Reference path identifier~~	~~32~~	–	–
~~LTP/FTP latitude~~	~~32~~	~~± 90.0°~~	~~0.0005 arcsec~~
~~LTP/FTP longitude~~	~~32~~	~~± 180.0°~~	~~0.0005 arcsec~~
~~LTP/FTP height~~	~~16~~	~~–512.0 to 6 041.5 m~~	~~0.1 m~~
~~ΔFPAP latitude~~	~~24~~	~~± 1.0°~~	~~0.0005 arcsec~~
~~ΔFPAP longitude~~	~~24~~	~~± 1.0°~~	~~0.0005 arcsec~~
~~Approach threshold crossing height (TCH) (Note 1)~~	~~15~~	~~0 to 1 638.35 m (0 to 3 276.7 ft)~~	~~0.05 m (0.1 ft)~~
~~Approach TCH units selector~~	~~1~~	–	–
~~Glide path angle (GPA)~~	~~16~~	~~0 to 90.0°~~	~~0.01°~~
~~Course width at threshold~~	~~8~~	~~80.0 to 143.75 m~~	~~0.25 m~~
~~ΔLength offset~~	~~8~~	~~0 to 2 032 m~~	~~8 m~~
~~Horizontal alert limit (HAL)~~	~~8~~	~~0 to 50.8 m~~	~~0.2 m~~
~~Vertical alert limit (VAL) (Note 2)~~	~~8~~	~~0 to 50.8 m~~	~~0.2 m~~
~~Final approach segment CRC~~	~~32~~	–	–

~~*Note 1.— Information can be provided in either feet or metres as indicated by the approach TCH unit sector.*~~

~~*Note 2.— VAL of 0 indicates that the vertical deviations are not to be used (i.e. a lateral guidance only approach).*~~

DATA CONTENT DESCRIPTION	BITS USED	RANGE OF VALUES	RESOLUTION	CODING RULES (Note 5)	PROCEDURE DESIGN VALUES PROVIDED	FAS DB VALUE USED	BINARY DEFINITION	BINARY REPRESENTATION (Note 1)	HEXADECIMAL REPRESENTATION
Operation Type	4	[0..15]	1	0 : Straight-in approach procedure 1..15 : Spare	Straight-In	0	$m_4..m_1$	0000	08
SBAS provider ID	4	[0..15]	1	0 : WAAS 1 : EGNOS 2 : MSAS 3..13 : Spare 14 : GBAS only 15 : Any SBAS provider	EGNOS	1	$m_8..m_5$	0001	
Airport ID	32	$\alpha_1\alpha_2\alpha_3\alpha_4$	-	α_1, α_2, α_3 = [0..9, A..Z] α4 = [<space>, 0..9, A..Z] D_{OUT} = ASCII value & 3F	LFBO	LFBO	$m_{40}..m_{33}$ $m_{32}..m_{25}$ $m_{24}..m_{17}$ $m_{16}..m_9$	'L' 00 001100 'F' 00 000110 'B' 00 000010 'O' 00 001111 (Note 2)	F0 40 60 30
Runway number	6	[01..36]	1	-	14	14	$m_{46}..m_{41}$	001110	72
Runway letter	2	[0..3]	1	0 : No letter 1 : Right (R) 2 : Centre (C) 3 : Left (L)	R	1	m_{48} m_{47}	01	
Approach performance designator	3	[0..7]	1	Not used by SBAS	0 (default value)	0	$m_{51}..m_{49}$	000	0B
Route indicator	5	α	-	α = [<space>, A..Z] α ≠ I and α ≠ O	Z	Z	$m_{56}..m_{52}$	11010	
Reference path data selector	8	[0..48]	-	Not used by SBAS	0 (default value)	0	$m_{64}..m_{57}$	00000000	00
Reference path identifier	32	$\alpha_1\alpha_2\alpha_3\alpha_4$	-	α_1 = [E, M, W] α_2, α_3 = [0..9] α_4 = [<space>, A, B, D..K, M..Q, S..Z] D_{OUT} = ASCII value & 3F	E14A	E14A	$m_{96}..m_{89}$ $m_{88}..m_{81}$ $m_{80}..m_{73}$ $m_{72}..m_{65}$	E' 00 000101 '1' 00 110001 '4' 00 110100 'A' 00 000001 (Note 2)	80 2C 8C A0

DATA CONTENT DESCRIPTION	BITS USED	RANGE OF VALUES	RESOLUTION	CODING RULES (Note 5)	PROCEDURE DESIGN VALUES PROVIDED	FAS DB VALUE USED	BINARY DEFINITION	BINARY REPRESENTATION (Note 1)	HEXADECIMAL REPRESENTATION
LTP/FTP latitude	32	[-90.0°..90.0°]	0.0005 arcsec	D_{CONV1} = D_{IN} -> rounding method (Note 3) D_{CONV2} = D_{CONV1} -> decimal (sec) D_{OUT} = D_{CONV2} x 2000 N : D_{OUT} S : Two's complement (D_{OUT})	D_{IN} = 43°38'38.8103" N	D_{CONV1} = 43°38'38.8105" N D_{CONV2} = 157118.8105 sec D_{OUT} = 314237621	$m_{128}..m_{121}$ $m_{120}..m_{113}$ $m_{112}..m_{105}$ $m_{104}..m_{97}$	00010010 10111010 11100010 10110101	AD 47 5D 48
LTP/FTP longitude	32	[-180.0°..180.0°]	0.0005 arcsec	D_{CONV1} = D_{IN} -> rounding method (Note 3) D_{CONV2} = D_{CONV1} -> decimal (sec) D_{OUT} = D_{CONV2} x 2000 E : D_{OUT} W : Two's complement (D_{OUT})	D_{IN} = 001°20'45.3591" E	D_{CONV1} = 001°20'45.3590" E D_{CONV2} = 4845.359 sec D_{OUT} = 9690718	$m_{160}..m_{153}$ $m_{152}..m_{145}$ $m_{144}..m_{137}$ $m_{136}..m_{129}$	00000000 10010011 11011110 01011110	7A 7B C9 00
LTP/FTP height	16	[-512..6041.5]	0.1m	D_{CONV} = round (D_{IN}, resolution) D_{OUT} = (D_{IN} + 512) x 10	D_{IN} = 148.74m	D_{CONV} = 148.7 D_{OUT} = 6607	$m_{176}..m_{169}$ $m_{168}..m_{161}$	00011001 11001111	F3 98
ΔFPAP latitude	24	[-1.0°..1.0°]	0.0005 arcsec	D_{CONV1} = D_{IN} -> rounding method (Note 3) D_{CONV2} = D_{CONV1} -> decimal (sec) D_{OUT} = D_{CONV2} x 2000 + : D_{OUT} - : Two's complement (D_{OUT})	D_{IN} = -0°01'37.8973"	D_{CONV1} = -00°01'37.8975" D_{CONV2} = -97.8975" D_{OUT} = Two's complement (195795) D_{OUT} = 16581421	$m_{200}..m_{193}$ $m_{192}..m_{185}$ $m_{184}..m_{177}$	11111101 00000011 00101101	B4 C0 BF
ΔFPAP longitude	24	[-1.0°..1.0°]	0.0005 arcsec	D_{CONV1} = D_{IN} -> rounding method (Note 3) D_{CONV2} = D_{CONV1} -> decimal (sec) D_{OUT} = D_{CONV2} x 2000 + : D_{OUT} - : Two's complement (D_{OUT})	D_{IN} = 0°01'41.9329"	D_{CONV1} = 0°01'41.9330" D_{CONV2} = 101.9330" D_{OUT} = 203866	$m_{224}..m_{217}$ $m_{216}..m_{209}$ $m_{208}..m_{201}$	00000011 00011100 01011010	5A 38 C0
Approach TCH	15	[0..1638.35m] [0..3276.7ft]	0.05m 0.1ft	D_{CONV} = round (D_{IN}, resolution) m : D_{OUT} = D_{IN} x 20 ft : D_{OUT} = D_{IN} x 10	D_{IN} = 15.00m	D_{CONV} = 15.00m D_{OUT} = 300	$m_{239}..m_{233}$ $m_{232}..m_{225}$	0000001 00101100	34 81
Approach TCH units selector	1	[0,1]	-	0 : feet 1 : meters	m	1	m_{240}	1	
Glide path angle (GPA)	16	[0..90.00°]	0.01°	D_{CONV} = round (D_{IN}, resolution) D_{OUT} = D_{IN} x 100	D_{IN} = 3.00°	D_{CONV} = 3.00° D_{OUT} = 300	$m_{256}..m_{249}$ $m_{248}..m_{241}$	00000001 00101100	34 80

DATA CONTENT DESCRIPTION	BITS USED	RANGE OF VALUES	RESOLUTION	CODING RULES (Note 5)	PROCEDURE DESIGN VALUES PROVIDED	FAS DB VALUE USED	BINARY DEFINITION	BINARY REPRESENTATION (Note 1)	HEXADECIMAL REPRESENTATION
Course width	8	[80.00m..143.75m]	0.25m	D_{CONV} = round (D_{IN}, resolution) D_{OUT} = (D_{CONV} - 80) x 4	D_{IN} = 105.00m	D_{CONV} = 105.00m D_{OUT} = 100	$m_{264}..m_{257}$	01100100	26
ΔLength offset	8	[0..2032m]	8m	D_{CONV} = round (D_{IN}, resolution) D_{OUT} = (integer division of D_{CONV} by 8) + 1 D_{OUT} = 255 : not provided value	D_{IN} = 284.86m	D_{CONV} = 288m D_{OUT} = 36	$m_{272}..m_{265}$	00100100	24
Horizontal alert limit (HAL)	8	[0..50.8m]	0.2m	D_{CONV} = round (D_{IN}, resolution) D_{OUT} = D_{IN} * 5	D_{IN} = 40.0m	D_{CONV} = 40.0m D_{OUT} = 200	$m_{280}..m_{273}$	11001000	13
Vertical alert limit (VAL)	8	[0..50.8m]	0.2m	D_{CONV} = round (D_{IN}, resolution) D_{OUT} = Value * 5 D_{OUT} = 0 : vertical deviations cannot be used	D_{IN} = 50.0m	D_{CONV} = 50.0m D_{OUT} = 250	$m_{288}..m_{281}$	11111010	5F
Final approach segment CRC	32	[0..2^{32}-1]		D_{OUT} = remainder (P(x) / Q(x))	-	-	$r_{32}..r_{25}$ $r_{24}..r_{17}$ $r_{16}..r_9$ $r_8..r_1$	10101110 11000011 01100100 10001111	75 C3 26 F1 (Note 4)

Notes.
1. The rightmost bit is the LSB of the binary parameter value and is the first bit transmitted to the CRC calculator.
2. The two most significant bits of each byte are set to 0 (see bold characters).
3. The rounding methodology is provided in the PANS-OPS (Doc 8168) Volume II.
4. The FAS CRC value is displayed in the order $r_{25}..r_{32}$, $r_{17}..r_{24}$, $r_9..r_{16}$, $r_1..r_8$ where r_i is th i^{th} coefficient of the remainder R(x) as defined in Appendix B, 3.9 .
5. D_{IN} : raw data value, D_{CONV} : converted data value according to coding rules, D_{OUT} : coded data value.

8.11.4 For aircraft receivers using early-late correlators and tracking GPS satellites, the precorrelation bandwidth of the installation, the correlator spacing and the differential group delay are within the ranges defined in Table D-11, except as noted below.

8.11.4.1 For GBAS airborne equipment using early-late correlators and tracking GPS satellites, the precorrelation bandwidth of the installation, the correlator spacing and the differential group delay are within the ranges defined in Table D-11, except that the region 1 minimum bandwidth will increase to 4 MHz and the average correlator spacing is reduced to an average of 0.21 chips or instantaneous of 0.235 chips.

…

Table D-13B. GPS tracking constraints for GBAS airborne receivers with double-delta correlators

Region	3 dB precorrelation bandwidth, BW	Average correlator spacing range (X) (chips)	Instantaneous correlator spacing range (chips)	Differential group delay
1	(–50 × X) + 12 < BW ≤ 7 MHz ~~2~~4 < BW ≤ 7 MHz	0.1 – ~~0.2~~0.16 ~~0.2~~ 0.16– 0.6	0.09 – ~~0.22~~0.18 ~~0.18~~ 0.14– 0.65	≤ 600 ns
2	(–50 × X) + 12 < BW ≤ (133.33 × X) + 2.667 MHz (–50 × X) + 12 < BW ≤ 14 MHz 7 < BW ≤ 14 MHz	0.07 – 0.085 0.085 – 0.1 0.1 – 0.24	0.063 – 0.094 0.077 – 0.11 0.09 – 0.26	≤ 150 ns
3	14 < BW ≤ 16 MHz ~~(133.33 × X) + 2.667 < BW ≤ 16 MHz~~ 14 < BW ≤ (133.33 × X) + 2.667 MHz	0.1 – 0.24 0.085 – 0.1	0.09 – 0.26 0.077 – 0.11	≤ 150 ns

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AMENDMENT No. 89

TO THE

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES
AND PROCEDURES FOR AIR NAVIGATION SERVICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME II
(COMMUNICATION PROCEDURES
INCLUDING THOSE WITH PANS STATUS)

The amendment to Annex 10, Volume II, contained in this document was adopted by the Council of ICAO on **3 March 2014**. Such parts of this amendment as have not been disapproved by more than half of the total number of Contracting States on or before **14 July 2014** will become effective on that date and will become applicable on **13 November 2014** as specified in the Resolution of Adoption. (State letters AN 13/2.5-13/16 and AN 13/2.5-13/34 refer.)

MARCH 2014

INTERNATIONAL CIVIL AVIATION ORGANIZATION

AMENDMENT 89 TO THE INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

RESOLUTION OF ADOPTION

The Council

Acting in accordance with the Convention on International Civil Aviation, and particularly with the provisions of Articles 37, 54 and 90 thereof,

1. *Hereby adopts* on 3 March 2014 Amendment 89 to the International Standards and Recommended Practices contained in the document entitled *International Standards and Recommended Practices and Procedures for Air Navigation Services — Aeronautical Telecommunications, Communication Procedures including those with PANS status* which for convenience is designated Annex 10, Volume II to the Convention;

2. *Prescribes* 14 July 2014 as the date upon which the said amendment shall become effective, except for any part thereof in respect of which a majority of the Contracting States have registered their disapproval with the Council before that date;

3. *Resolves* that the said amendment or such parts thereof as have become effective shall become applicable on 13 November 2014;

4. *Requests the Secretary General*:

a) to notify each Contracting State immediately of the above action and immediately after 14 July 2014 of those parts of the amendment which have become effective;

b) to request each Contracting State:

1) to notify the Organization (in accordance with the obligation imposed by Article 38 of the Convention) of the differences that will exist on 13 November 2014 between its national regulations or practices and the provisions of the Standards in the Annex as hereby amended, such notification to be made before 13 October 2014, and thereafter to notify the Organization of any further differences that arise;

2) to notify the Organization before 13 October 2014 of the date or dates by which it will have complied with the provisions of the Standards in the Annex as hereby amended;

c) to invite each Contracting State to notify additionally any differences between its own practices and those established by the Recommended Practices, when the notification of such differences is important for the safety of air navigation, following the procedure specified in subparagraph b) above with respect to differences from Standards.

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NOTES ON THE PRESENTATION OF THE AMENDMENT TO ANNEX 10, VOLUME II

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

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

2. The sources of the proposed amendment are the SASP and OPLINK panels.

TEXT OF AMENDMENT 89 TO THE

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME II

(COMMUNICATION PROCEDURES INCLUDING THOSE WITH PANS STATUS)

CHAPTER 1. DEFINITIONS

…

1.8 Data link communications

…

Downstream data authority. A designated ground system, different from the current data authority, through which the pilot can contact an appropriate ATC unit for the purposes of receiving a downstream clearance.

Free text message element. A message element used to convey information not conforming to any standardized message element in the CPDLC message set.

Next data authority. The ground system so designated by the current data authority through which an onward transfer of communications and control can take place.

Pre-formatted free text message element. A free text message element that is stored within the aircraft system or ground system for selection.

Standardized free text message element. A message element that uses a defined free text message format, using specific words in a specific order.

Note.— Standardized free text message elements may be manually entered by the user or pre-formatted.

…

CHAPTER 8. AERONAUTICAL MOBILE SERVICE – DATA LINK COMMUNICATIONS

…

8.2 CPDLC PROCEDURES

…

8.2.9 Exchange of operational CPDLC messages

…

8.2.9.5.2 When considered necessary by the appropriate ATS authority, additional ~~pre-formatted~~ standardized free text message~~s~~ elements shall be made available ~~to the~~and used by controllers and pilots for those occasions where the CPDLC message set contained in the PANS-ATM does not provide for specific requirements. In such cases, a list of ~~pre-formatted~~standardized free text message~~s~~ elements shall be established by the appropriate ATS authority, in consultation with operators and other ATS authorities that may be concerned.

8.2.9.5.3 Information concerning CPDLC message elements subset utilized and, if applicable, any additional ~~pre-formatted~~standardized free text message~~s~~ elements shall be published in aeronautical information publications.

8.2.9.5.4 PANS.— *Standardized free text message elements should be pre-formatted to facilitate their use.*

…

8.2.11 Free text messages

PANS. — *The use of free text message~~s~~ elements by controllers or pilots, other than ~~pre-formatted~~ standardized free text messages referred to in paragraph 8.2.9.5.2, should be avoided.*

Note.— Whilst it is recognized that non-routine and emergency situations may necessitate the use of free text, particularly when voice communication has failed, the avoidance of utilizing free text messages is intended to reduce the possibility of misinterpretation and ambiguity.

…

8.2.12 Emergencies, hazards and equipment failure procedures

8.2.12.1 **PANS.—** *When a CPDLC emergency message is received, the controller shall acknowledge receipt of the message by the most efficient means available.*

8.2.12.2 **PANS.—** *When responding via CPDLC to a report indicating unlawful interference, uplink message* ROGER 7500 *shall be used.*

8.2.12.3 **PANS.—** *When responding via CPDLC to all other emergency or urgency messages, uplink message* ROGER *shall be used.*

8.2.12.4 When a CPDLC message requires a logical acknowledgement and/or an operational response, and such a response is not received, the pilot or controller, as appropriate, shall be alerted.

8.2.12.5 *Failure of CPDLC*

Note 1.— Action to be taken in the event of a CPDLC initiation failure is covered in 8.2.12.6.

Note ~~1~~2.— Action to be taken in the event of the failure of a single CPDLC message is covered in 8.2.12.~~7~~8.

8.2.12.5.1 **Recommendation.—** *A CPDLC failure should be detected in a timely manner.*

…

8.2.12.6 *Initiation failure of CPDLC*

8.2.12.6.1 **PANS.—** *In the case of an initiation failure, the data link system shall provide an indication of the failure to the ATS unit and the flight crew.*

8.2.12.6.2 **PANS.—** *The ATS unit shall establish procedures to resolve, as soon as practicable, initiation failures. Procedures should include, as a minimum, the following:*

a) when a flight plan is available, verify that the aircraft identification, aircraft registration, and other details contained in the data link initiation request correspond with details in the flight plan, and where differences are detected make the necessary changes; or

b) when a flight plan is not available, create a flight plan with sufficient information in the flight data processing system, to achieve a successful data link initiation; then

c) arrange for the re-initiation of the data link process.

8.2.12.6.3 **PANS.—** *The aircraft operator shall establish procedures to resolve, as soon as practicable, initiation failures. Procedures should include, as a minimum, that the pilot:*

a) verify the correctness and consistency of the flight plan information available in the FMS or equipment from which the CPDLC communication is initiated, and where differences are detected make the necessary changes; then

b) re-initiate data link.

…

Renumber subsequent paragraphs.

— END —

AMENDMENT No. 89

TO THE

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME IV
(SURVEILLANCE AND COLLISION AVOIDANCE SYSTEMS)

The amendment to Annex 10, Volume IV, contained in this document was adopted by the Council of ICAO on **3 March 2014**. Such parts of this amendment as have not been disapproved by more than half of the total number of Contracting States on or before **14 July 2014** will become effective on that date and will become applicable on **13 November 2014** as specified in the Resolution of Adoption. (State letter AN 7/1.3.100-12/23 refers.)

MARCH 2014

INTERNATIONAL CIVIL AVIATION ORGANIZATION

APPENDIX A

AMENDMENT 89 TO THE INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

RESOLUTION OF ADOPTION

The Council

Acting in accordance with the Convention on International Civil Aviation, and particularly with the provisions of Articles 37, 54 and 90 thereof,

1. *Hereby adopts* on 3 March 2014 Amendment 89 to the International Standards and Recommended Practices contained in the document entitled *International Standards and Recommended Practices — Aeronautical Telecommunications, Surveillance and Collision Avoidance Systems* which for convenience is designated Annex 10, Volume IV to the Convention;

2. *Prescribes* 14 July 2014 as the date upon which the said amendment shall become effective, except for any part thereof in respect of which a majority of the Contracting States have registered their disapproval with the Council before that date;

3. *Resolves* that the said amendment or such parts thereof as have become effective shall become applicable on 13 November 2014;

4. *Requests the Secretary General*:

a) to notify each Contracting State immediately of the above action and immediately after 14 July 2014 of those parts of the amendment which have become effective;

b) to request each Contracting State:

1) to notify the Organization (in accordance with the obligation imposed by Article 38 of the Convention) of the differences that will exist on 13 November 2014 between its national regulations or practices and the provisions of the Standards in the Annex as hereby amended, such notification to be made before 13 October 2014, and thereafter to notify the Organization of any further differences that arise;

2) to notify the Organization before 13 October 2014 of the date or dates by which it will have complied with the provisions of the Standards in the Annex as hereby amended;

c) to invite each Contracting State to notify additionally any differences between its own practices and those established by the Recommended Practices, when the notification of such differences is important for the safety of air navigation, following the procedure specified in subparagraph b) above with respect to differences from Standards.

— — — — — — — —

NOTES ON THE PRESENTATION OF THE AMENDMENT TO ANNEX 10, VOLUME IV

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

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

2. The source of the proposed amendment is the Aeronautical Surveillance Panel (ASP).

TEXT OF AMENDMENT 89 TO THE

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME IV (SURVEILLANCE AND COLLISION AVOIDANCE SYSTEMS)

CHAPTER 2. GENERAL

2.1.5 Mode S airborne equipment capability

2.1.5.1 All Mode S transponders shall conform to one of the following five levels:

Note. — The transponder used for a Mode S site monitor may differ from the requirements defined for a normal Mode S transponder. For example, it may be necessary to reply to all-call interrogations when on the ground. For more details see the Aeronautical Surveillance Manual *(Doc 9924) Appendix D.*

…

2.1.5.1.2 Level 2 — Level 2 transponders shall have the capabilities of 2.1.5.1.1 and also those prescribed for:

a) standard length communications (Comm-A and Comm-B) (3.1.2.6.2, 3.1.2.6.4, 3.1.2.6.6, 3.1.2.6.8 and 3.1.2.6.11);

b) data link capability reporting (3.1.2.6.10.2.2); ~~and~~

c) aircraft identification reporting (3.1.2.9); and

d) data parity with overlay control (3.1.2.6.11.2.5) for equipment certified on or after 1 January 2020.

2.2 HUMAN FACTORS CONSIDERATIONS

Recommendation.— *Human Factors principles should be observed in the design and certification of surveillance radar, transponder and collision avoidance systems.*

Note.— Guidance material on Human Factors principles can be found in Doc 9683, Human Factors Training Manual and Circular 249 (Human Factors Digest No. 11 — Human Factors in CNS/ATM Systems).

2.2.1 Operation of controls

2.2.1.1 Transponder controls which are not intended to be operated in flight shall not be directly accessible to the flight crew.

2.2.1.2 **Recommendation.—** *The operation of transponder controls, intended for use during flight, should be evaluated to ensure they are logical and tolerant to human error. In particular, where transponder functions are integrated with other system controls, the manufacturer should ensure that unintentional transponder mode switching (i.e. an operational state to 'STANDBY' or 'OFF') is minimized.*

Note.— This may take the form of a confirmation of mode switching, required by the flight crew. Typically 'Line Select' Keys, 'Touch Screen' or 'Cursor Controlled/Tracker-ball' methods used to change transponder modes should be carefully designed to minimize flight crew error.

2.2.1.3 **Recommendation.—** *The flight crew should have access at all times to the information of the operational state of the transponder.*

Note.—Information on the monitoring of the operational state of the transponder is provided in RTCA DO-181 E, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/ Mode Select (ATCRBS/Mode S) Airborne Equipment, *and in* EUROCAE ED-73E, Minimum Operational Performance Specification for Secondary Surveillance Radar Mode S Transponders.

CHAPTER 3. SURVEILLANCE SYSTEMS

3.1.1 Systems having only Mode A and Mode C capabilities

…

3.1.1.7.9 *REPLY RATE*

3.1.1.7.9.1 All transponders shall be capable of continuously generating at least 500 replies per second for a 15-pulse coded reply. Transponder installations used solely below 4 500 m (15 000 ft), or below a lesser altitude established by the appropriate authority or by regional air navigation agreement, and in aircraft with a maximum cruising true airspeed not exceeding 175 kt (324 km/h) shall be capable of generating at least 1 000 15-pulse coded replies per second for a duration of 100 milliseconds. Transponder installations operated above 4 500 m (15 000 ft) or in aircraft with a maximum cruising true airspeed in excess of 175 kt (324 km/h), shall be capable of generating at least 1 200 15-pulse coded replies per second for a duration of 100 milliseconds.

Note 1.— A 15-pulse reply includes 2 framing pulses, 12 information pulses, and the SPI pulse.

Note 2.— The reply rate requirement of 500 replies per second establishes the minimum continuous reply rate capability of the transponder. As per the altitude and speed criteria above, the 100 or 120 replies in a 100 millisecond interval defines the peak capability of the transponder. The transponder must be capable of replying to this short term burst rate, even though the transponder may not be capable of sustaining this rate. If the transponder is subjected to interrogation rates beyond its reply rate capability, the reply rate limit control of 3.1.1.7.9.2 acts to gracefully desensitize the transponder in a manner that favours closer interrogators. Desensitization eliminates weaker interrogation signals.

3.1.2 Systems having Mode S capabilities

…

3.1.2.1.1 *Interrogation carrier frequency.* The carrier frequency of all interrogations (uplink transmissions) from ground facilities with Mode S capabilities shall be 1 030 plus or minus 0.01 MHz, except during the phase reversal, while maintaining the spectrum requirements of 3.1.2.1.2.

Note. – During the phase reversal the frequency of the signal may shift by several MHz before returning to the specified value.

…

3.1.2.1.4.2.1 *Phase reversal duration.* The duration of the phase reversal shall be less than 0.08 microsecond and the phase shall advance (or retard) monotonically throughout the transition region. There shall be no amplitude modulation applied during the phase transition.

Note 1.— The minimum duration of the phase reversal is not specified. Nonetheless, the spectrum requirements of 3.1.2.1.2 must be met.

Note 2.— The phase reversal can be generated using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or other techniques with little or no amplitude drop, but with frequency shift during the phase reversal and slow phase reversal (80ns). A demodulator cannot make any assumption on the type of modulation technology used and therefore cannot rely on the specificities of the signal during the phase reversal to detect a phase reversal.

…

3.1.2.1.5.1 *Intermode interrogation*

3.1.2.1.5.1.1 *Mode A/C/S all-call interrogation.* This interrogation shall consist of three pulses: P_1, P_3, and the long P_4 as shown in Figure 3-3. One or two control pulses (P_2 alone, or P_1 and P_2) shall be transmitted using a separate antenna pattern to suppress responses from aircraft in the side lobes of the interrogator antenna.

Note.— The Mode A/C/S all-call interrogation elicits a Mode A or Mode C reply (depending on the P_1-P_3 pulse spacing) from a Mode A/C transponder because it does not recognize the P_4 pulse. A Mode S transponder recognizes the long P_4 pulse and responds with a Mode S reply. This interrogation was originally planned for use by isolated or clustered interrogators. Lockout for this interrogation was based on the use of II equals 0. The development of the Mode S subnetwork now dictates the use of a non-zero II code for communication purposes. For this reason, II equals 0 has been reserved for use in support of a form of Mode S acquisition that uses stochastic/lockout override (3.1.2.5.2.1.4 and 3.1.2.5.2.1.5). The Mode A/C/S all-call cannot be used with full Mode S operation since II equals 0 can only be locked out for short time periods (3.1.2.5.2.1.5.2.1). This interrogation cannot be used with stochastic/lockout override, since probability of reply cannot be specified.

3.1.2.1.5.1.1.1 Mode A/C/S all-call interrogations shall not be used on or after 1 January 2020.

Note 1.— The use of Mode A/C/S all-call interrogations does not allow the use of stochastic lockout override and therefore might not ensure a good probability of acquisition in areas of high density of flights or when other interrogators lockout transponder on II=0 for supplementary acquisition.

Note 2.— The replies to Mode A/C/S all-call interrogations will no longer be supported by equipment certified on or after 1 January 2020 in order to reduce the RF pollution generated by the replies triggered by the false detection of Mode A/C/S all-call interrogations within other types of interrogation.

3.1.2.3 MODE S DATA STRUCTURE

3.1.2.3.2 *FORMATS OF MODE S INTERROGATIONS AND REPLIES*

…

3.1.2.3.2.1.4 *PI: Parity/interrogator identifier.* This 24-bit (33-56) or (89-112) downlink field shall have parity overlaid on the interrogator's identity code according to 3.1.2.3.3.2 and shall appear in the Mode S all-call reply, DF = 11 and in the extended squitter, DF = 17 or DF = 18. If the reply is made in response to a Mode A/C/S all-call, a Mode S-only all-call with CL field (3.1.2.5.2.1.3) and IC field (3.1.2.5.2.1.2) equal to 0, or is an acquisition or an extended squitter (3.1.2.8.5, 3.1.2.8.6 or 3.1.2.8.7), the II and the SI codes shall be 0.

3.1.2.3.2.1.5 *DP: Data parity.* This 24-bit (89 – 112) downlink field shall contain the parity overlaid on a "Modified AA" field which is established by performing a modulo-2 summation (e.g. Exclusive-Or function) of the discrete address most significant 8 bits and BDS1, BDS2 where BDS1 (3.1.2.6.11.2.2) and BDS2 (3.1.2.6.11.2.3) are provided by the "RR" (3.1.2.6.1.2) and "RRS" (3.1.2.6.1.4.1) as specified in 3.1.2.6.11.2.2 and 3.1.2.6.11.2.3.

Example:

Discrete address	=	AA AA AA Hex	=	1010	1010	1010	1010	1010	1010
BDS1, BDS2	=	5F 00 00 Hex	=	0101	1111	0000	0000	0000	0000
Discrete address	⊕	BDS1, BDS2 Hex	=	1111	0101	1010	1010	1010	1010
"Modified AA"	=	F5 AA AA Hex	=	1111	0101	1010	1010	1010	1010

where "⊕" prescribes modulo-2 addition
The resulting "Modified AA" field then represents the 24 bit sequence (a1, a2…a24) that shall be used to generate the DP field in accordance with paragraph 3.1.2.3.3.2.

The DP field shall be used in DF=20 and DF=21 replies if the transponder is capable of supporting the DP field and if the overlay control (OVC - 3.1.2.6.1.4.1.i) bit is set to one (1) in the interrogation requesting downlink of GICB registers.

…

3.1.2.4 GENERAL INTERROGATION-REPLY PROTOCOL

…

3.1.2.4.1.3.2.1 *Replies to intermode interrogations.* A Mode S reply with downlink format 11 shall be transmitted in accordance with the provisions of 3.1.2.5.2.2 when a Mode A/C/S all-call interrogation has been accepted. Equipment certified on or after 1 January 2020 shall not reply to Intermode Mode A/C/S all-call interrogations.

Note.— Since Mode S transponders do not accept Mode A/C-only all-call interrogations, no reply is generated.

…

3.1.2.5 INTERMODE AND MODE S ALL-CALL TRANSACTIONS

3.1.2.5.2.1.4 *Operation based on lockout override*

…

c) *for a reply probability equal to 0.25 or less:*

the smaller of 10 interrogations per 3 dB beam dwell or 125 interrogations per second.

Note.— These limits have been defined in order to minimize the RF pollution generated by such a method while keeping a minimum of replies to allow acquisition of aircraft within a beam dwell.

3.1.2.5.2.1.4.2 **Recommendation.—** *Passive acquisition without using all-call interrogations should be used in the place of lockout override.*

Note.— The Aeronautical Surveillance Manual *(Doc 9924) provides guidance on different passive acquisition methods.*

3.1.2.5.2.1.4.3 *Field content for a selectively addressed interrogation used by an interrogator without an assigned interrogator code.* An interrogator that has not been assigned with a unique discrete interrogator code and is authorized to transmit shall use the II code 0 to perform the selective interrogations. In this case, selectively addressed interrogations used in connection with acquisition using lockout override shall have interrogation field contents restricted as follows:

…

3.1.2.5.2.2 *All-call reply, downlink format 11*

…

3.1.2.5.2.2.1 *CA: Capability.* This 3-bit (6-8) downlink field shall convey information on the transponder level, the additional information below, and shall be used in formats DF=11 and DF=17.

Coding

0 signifies Level 1 transponder (surveillance only), and no ability to set CA code 7 and either airborne or on the ground
1 reserved
2 reserved
3 reserved
4 signifies Level 2 or above transponder and ability to set CA code 7 and on the ground
5 signifies Level 2 or above transponder and ability to set CA code 7 and airborne
6 signifies Level 2 or above transponder and ability to set CA code 7 and either airborne or on the ground
7 signifies the DR field is not equal to 0 or the FS field equals 2, 3, 4 or 5, and either airborne or on the ground

When the conditions for CA code 7 are not satisfied, aircraft with Level 2 or above transponders:

a) that do not have automatic means to set the on-the-ground condition shall use CA code 6;

b) with automatic on-the-ground determination shall use CA code 4 when on the ground and 5 when airborne; and

~~c) with or without automatic on-the-ground determination shall use CA = 4 when commanded to set and report the on-the-ground status via the TCS subfield (3.1.2.6.1.4.1 f)).~~

3.1.2.6 ADDRESSED SURVEILLANCE AND STANDARD LENGTH COMMUNICATION TRANSACTIONS

3.1.2.6.1 *SURVEILLANCE, ALTITUDE REQUEST, UPLINK FORMAT 4*

…

3.1.2.6.1.1 *PC: Protocol.* This 3-bit, (6-8) uplink field shall contain operating commands to the transponder. The PC field values 2 through 7 shall be ignored and the values 0 and 1 shall be processed for ~~the processing of~~ surveillance or Comm-A interrogations containing DI = 3 (3.1.2.6.1.4.1).

…

3.1.2.6.1.3 *DI: Designator identification.* This 3-bit (14-16) uplink field shall identify the structure of the SD field (3.1.2.6.1.4).

Coding

0	signifies SD not assigned except for IIS, bits 21-27 and 29-32 are not assigned, and bit 28 contains the “OVC” (overlay control - 3.1.2.6.1.4.1.i).
1	signifies SD contains multisite and communications control information
2	signifies SD contains control data for extended squitter
3	signifies SD contains SI multisite lockout, broadcast and GICB control information, and bit 28 contains the “OVC” (overlay control - 3.1.2.6.1.4.1.i).
4-6	signifies SD not assigned
7	signifies SD contains extended data readout request, multisite and communications control information, and bit 28 contains the “OVC” (overlay control - 3.1.2.6.1.4.1.i).

3.1.2.6.1.4 *SD: Special designator.* This 16-bit (17-32) uplink field shall contain control codes which depend on the coding in the DI field.

Note.— The special designator (SD) field is provided to accomplish the transfer of multisite, lockout and communications control information from the ground station to the transponder.

DI CODE — *SD FIELD STRUCTURE*

DI CODE					
	17	21	28	29	
0	IIS	Reserved	OVC	Reserved	
	20	27	28	32	

DI CODE						
	17	21	23	26	27	29
1	IIS	MBS	MES	LOS	RSS	TMS
	20	22	25	26	28	32

DI CODE					
	17	21	24	27	29
2	Reserved	TCS	RCS	SAS	Reserved
	20	23	26	28	32

DI CODE					
	17	23	24	28	29
3	SIS	LSS	RSS	OVC	Reserved
	22	23	27	28	32

DI CODE							
	17	21	25	26	27	28	29
7	IIS	RRS	Reserved	LOS	Reserved	OVC	TMS
	20	24	25	26	27	28	32

3.1.2.6.1.4.1 *Subfields in SD.* The SD field shall contain information as follows:

a) If DI = 0, 1 or 7:

…

f) If DI = 2:

TCS, the 3-bit (21-23) type control subfield in SD shall control the ~~on-the-ground status~~ extended squitter airborne and surface format types reported by the transponder, and its response to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations. The following codes have been assigned:

0 signifies no ~~on-the-ground status~~ surface format types or reply inhibit command
1 signifies surface format types ~~set and report the on-the-ground status~~ for the next 15 seconds (see 3.1.2.6.1.4.2)
2 signifies surface format types ~~set and report the on-the-ground status~~ for the next 60 seconds (see 3.1.2.6.1.4.3)
3 signifies cancel ~~the on-the-ground command~~ surface format types and reply inhibit commands
4-7 ~~not assigned~~ reserved.

The transponder shall be able to accept a new command ~~to set or cancel the on-the-ground status~~ even though a prior command has not as yet timed out.

~~*Note Cancellation of the on-the-ground status command signifies that the determination of the vertical status reverts to the aircraft technique for this purpose. It does not signify a command to change to the vertical status.*~~

RCS, the 3-bit (24-26) rate control subfield in SD shall control the squitter rate of the transponder when it is reporting the extended squitter surface type formats. This subfield shall have no effect on the transponder squitter rate when it is reporting the extended squitter airborne ~~position~~ type formats. The following codes have been assigned:

0 signifies no surface ~~position~~ extended squitter rate command
1 signifies report high surface ~~position~~ extended squitter rate for 60 seconds
2 signifies report low surface ~~position~~ extended squitter rate for 60 seconds
~~3 signifies suppress all surface position extended squitters for 60 seconds~~
~~4 signifies suppress all surface position extended squitters for 120 seconds~~
~~5~~3-7 ~~not assigned~~ reserved.

Note 1.— The definition of high and low extended squitter rates is given in 3.1.2.8.6.4~~.3~~ and applies to the surface position, aircraft identification and category, and the operational status messages.

Note 2.— As stated in 3.1.2.8.5.2 d), acquisition squitters are transmitted when surface ~~position~~ type format extended squitters are ~~suppressed by using RCS=3 or 4~~ not being transmitted.

SAS, the 2-bit (27-28) surface antenna subfield in SD shall control the selection of the transponder diversity antenna that is used for (1) the extended squitter when the transponder is reporting the surface type formats, and (2) the acquisition squitter when the transponder is reporting the on-the-ground status. This subfield shall have no effect on the transponder diversity antenna selection when it is reporting the airborne status. The following codes have been assigned:

0 signifies no antenna command
1 signifies alternate top and bottom antennas for 120 seconds
2 signifies use bottom antenna for 120 seconds
3 signifies return to the default.

Note.— The top antenna is the default condition (3.1.2.8.6.5).

g) If DI = 3

SIS, the 6-bit (17-22) surveillance identifier subfield in SD shall contain an assigned surveillance identifier code of the interrogator (3.1.2.5.2.1.2.4).

LSS, the 1-bit (23) lockout surveillance subfield, if set to 1, shall signify a multisite lockout command from the interrogator indicated in SIS. If set to 0, LSS shall signify that no change in lockout state is commanded.

RRS, the 4-bit (24-27) reply request subfield in SD shall contain the BDS2 code of a requested GICB register.

Bits 28 to 32 are not assigned.

…

h) If DI=4, 5 or 6 then the SD field has no meaning and shall not impact other transaction cycle protocols. These DI codes remain reserved until future assignment of the SD field.

i) If DI = 0, 3, or 7:

In addition to the requirements provided above, the “SD” shall contain the following:
“OVC”: The 1-bit (bit 28) “overlay control” subfield in “SD” is used by the interrogator to command that the data parity (“DP” - 3.1.2.3.2.1.5) be overlaid upon the resulting reply to the interrogation in accordance with paragraph 3.1.2.6.11.2.5.

3.1.2.6.1.4.2 *TCS subfield equal to one (1) in the SD field for extended squitters.* When the TCS subfield in the SD field is set equal to one (1), it shall signify the following:

a) broadcast of the extended squitter surface formats, including the surface position message (3.1.2.8.6.4.3), the identification and category message (3.1.2.8.6.4.4), the aircraft operational status message (3.1.2.8.6.4.6) and the aircraft status message (3.1.2.8.6.4.6) for the next 15 seconds at the appropriate rates on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (3.1.2.6.1.4.1.f).

b) inhibit replies to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations for the next 15 seconds.

c) broadcast of acquisition squitters as per 3.1.2.8.5 using antenna as specified in 3.1.2.8.5.3.a.

d) does not impact the air/ground state reported via the CA, FS and VS fields.

e) discontinue broadcast of the extended squitter airborne message formats.

f) broadcast of the extended squitter surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

3.1.2.6.1.4.3 *TCS subfield equal to two (2) in the SD field for extended squitters.* When the TCS subfield in the SD field is set equal to two (2), it shall signify the following:

a) broadcast of the extended squitter surface formats, including the surface position message (3.1.2.8.6.4.3), the identification and category message (3.1.2.8.6.4.4), the aircraft operational status message (3.1.2.8.6.4.6) and the aircraft status message (3.1.2.8.6.4.6) for the next 60 seconds at the appropriate rates on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (3.1.2.6.1.4.1.f);

b) inhibit replies to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations for the next 60 seconds;

c) broadcast of acquisition squitters as per 3.1.2.8.5 using antenna as specified in 3.1.2.8.5.3.a;

d) does not impact the air/ground state reported via the CA, FS and VS fields;

e) discontinue broadcast of the extended squitter airborne message formats; and

f) broadcast of the extended squitter surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

3.1.2.6.1.5 *PC and SD field processing.* When DI = 1, PC field processing shall be completed before processing the SD field.

…

3.1.2.6.9 LOCKOUT PROTOCOLS

Note.— Non-selective all-call lockout and multisite lockout are not mutually exclusive. Interrogators using multisite lockout protocols for interrogator networking coordination may use non-selective lockout commands in the same interrogation. For example, the non-selective lockout may be used to prevent Mode S transponder replies with DF=11 to wrongly detected Mode A/C/S all-call interrogations from Mode A/C-only all-call interrogations. This is because of the misinterpretation of the narrow P4 pulse as a wide P4 pulse.

3.1.2.6.9.1 *Multisite all-call lockout*

Note.— The multisite lockout protocol prevents transponder acquisition from being denied one ground station by lockout commands from an adjacent ground station that has overlapping coverage.

3.1.2.6.9.1.1 The multisite lockout command shall be transmitted …. all-call lockout (3.1.2.6.9.2).

Note 1.— Fifteen interrogators can send independent multisite II lockout commands. In addition, 63 interrogators can send independent SI lockout commands. Each of these lockout commands must be timed separately.

Note 2.— Multisite lockout (which only uses non-zero II codes) does not affect the response of the transponder to Mode S-only all-call interrogations containing II equals 0 or to Mode A/C/S all-call interrogations.

3.1.2.6.9.2 *Non-selective all-call lockout*

…

Note 2.— Non-selective lockout does not affect the response of the transponder to Mode S-only all-call interrogations containing II not equal to 0.

3.1.2.6.10 BASIC DATA PROTOCOLS

…

3.1.2.6.10.1.2 *Ground report.* The on-the-ground status of the aircraft shall be reported in the CA field (3.1.2.5.2.2.1), the FS field (3.1.2.6.5.1), and the VS field (3.1.2.8.2.1). If an automatic indication of the on-the-ground condition (e.g., from a weight on wheels or strut switch) is available at the transponder data interface, it shall be used as the basis for the reporting of on-the-ground status except as specified in 3.1.2.6.10.3.1 ~~and 3.1.2.8.6.7~~. If such indication is not available at the transponder data interface (3.1.2.10.5.1.3), the FS and VS codes shall indicate that the aircraft is airborne and the CA field shall indicate that the aircraft is either airborne or on the ground (CA = 6) ~~except as indicated in 3.1.2.8.6.7~~.

…

3.1.2.6.10.3.1 Aircraft with an automatic means for determining the on-the-ground state on which transponders have access to at least one of the parameters, ground speed, radio altitude or airspeed, shall perform the following validation check:

If the automatically determined air/ground status is not available or is “airborne”, no validation shall be performed. If the automatically determined air/ground status is available and “on-the-ground” condition is being reported ~~or if the on-the-ground status has been commanded via the TCS subfield (3.1.2.6.1.4.1 f)~~), the air/ground status shall be overridden and changed to “airborne” if:

Ground Speed > 100 knots OR Airspeed > 100 knots OR Radio Altitude > 50 feet

3.1.2.6.11.2 *Ground-initiated Comm-B*

…

3.1.2.6.11.2.3 *BDS2 code.* The BDS2 code shall be as defined in the RRS subfield of the SD field (3.1.2.6.1.4.1) when DI=7 or DI=3. If no BDS2 code is specified (i.e., DI is not equal to either 7 or 3) it shall signify that BDS2 = 0.

3.1.2.6.11.2.4 *Protocol.* On receipt of such a request, the MB field of the reply shall contain the contents of the requested ground-initiated Comm-B register.

3.1.2.6.11.2.4.1 If the requested register is not serviced by the aircraft installation, the transponder shall reply and the MB field of the reply shall contain all ZEROs.

…

3.1.2.6.11.2.5 *Overlay control.* If the “DI” code of the Comm-B requesting interrogation is 0, 3, or 7, the “SD” contains the overlay control (OVC) field in accordance with paragraph 3.1.2.6.1.4.1.i.

a) If the “OVC” is equal to “1,” then the reply to the interrogation shall contain the “DP” (data parity) field in accordance with paragraph 3.1.2.3.2.1.5; and

b) If the “OVC” is equal to “0,” then the reply to the interrogation shall contain the “AP” field in accordance with paragraph 3.1.2.3.2.1.3.

3.1.2.8 AIR-AIR SERVICE AND SQUITTER TRANSACTIONS

…

3.1.2.8.4 *AIR-AIR TRANSACTION PROTOCOL*

Note.— Interrogation-reply coordination for the air-air formats follows the protocol outlined in Table 3-5 (3.1.2.4.1.3.2.2).

The most significant bit (bit 14) of the RI field of an air-air reply shall replicate the value of the AQ field (bit 14) received in an interrogation with UF equals 0.

If AQ equals 0 in the interrogation, the RI field of the reply shall contain the value 0 ~~(no operating ACAS) or ACAS information as indicated in 3.1.2.8.2.2 and 4.3.8.4.1.2~~.

If AQ equals 1 in the interrogation, the RI field of the reply shall contain the maximum cruising true airspeed capability of the aircraft as defined in 3.1.2.8.2.2.

In response to a UF = 0 with RL = 1 and DS ≠ 0, the transponder shall reply with a DF = 16 reply in which the MV field shall contain the contents of the GICB register designated by the DS value~~. In response to a UF = 0 with RL = 1 and DS = 0, the transponder shall reply with a DF = 16 with an MV field of all zeros. Receipt of a UF = 0 with DS ≠ 0 but RL = 0 shall have no associated ACAS cross-link action, and the transponder shall reply as specified in 3.1.2.8.2.2.~~ If the requested register is not serviced by the aircraft installation, the transponder shall reply and the MV field of the reply shall contain all ZEROs.

3.1.2.8.6 *EXTENDED SQUITTER, DOWNLINK FORMAT 17*

…

3.1.2.8.6.2 *ME: Message, extended squitter.* This 56-bit (33-88) downlink field in DF = 17 shall be used to transmit broadcast messages. Extended squitter shall be supported by registers 05, 06, 07, 08, 09, 0A {HEX} and 61-6F {HEX} and shall conform to either version 0, ~~or~~ version 1, or version 2 message formats as described below:

a) Version 0 ES message formats and related requirements ~~are suitable for early implementation of extended squitter applications.~~ report ~~S~~surveillance quality ~~is reported~~ by navigation uncertainty category (NUC), which can be an indication of either the accuracy or integrity of the navigation data used by ADS-B. However, there is no indication as to which of these, integrity or accuracy, the NUC value is providing an indication of.

b) Version 1 ES message formats and related requirements ~~apply to more advanced ADS-B applications.~~ report ~~S~~surveillance accuracy and integrity ~~are reported~~ separately as navigation accuracy category (NAC), navigation integrity category (NIC) and surveillance integrity level (SIL). Version 1 ES formats also include provisions for enhanced reporting of status information; and

c) Version 2 ES message formats and related requirements contain the provisions of version 1 but further enhance integrity and parameter reporting. Version 2 ES formats separately report position source integrity from the integrity of the ADS-B transmitting equipment. Version 2 ES formats also separate vertical accuracy reporting from horizontal position accuracy, remove vertical integrity from position integrity, and provide for the reporting of the SSR Mode A code, GNSS antenna offset and additional horizontal position integrity values. Version 2 ES formats also modify the target state report to include selected altitude, selected heading, and barometric pressure setting.

Note 1.— The formats and update rates of each register are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). The formats and update rates for individual squitters are defined by the version number of the extended squitter.*

Note 2.— The formats for the ~~two~~ three different versions are interoperable. An extended squitter receiver can recognize and decode ~~both~~ signals of its own version, as well as lower versions ~~version 0 and version 1~~ message formats. The receiver, however, can decode higher version signals according to its own capability.

Note 3.— Guidance material on transponder register formats and data sources is included in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.8.6.3 *Extended squitter types*

3.1.2.8.6.3.1 *Airborne position squitter.* The airborne position extended squitter type shall use format DF = 17 with the contents of GICB register 05 {HEX} inserted in the ME field.

Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 5 will cause the resulting reply to contain the airborne position ~~report~~ message in its MB field.

3.1.2.8.6.3.1.1 *SSS, surveillance status subfield in ME.* The transponder shall report the surveillance status of the transponder in this 2-bit (38, 39) subfield of ME when ME contains an airborne position message ~~squitter report~~.

Coding
0 signifies no status information
1 signifies transponder reporting permanent alert condition (3.1.2.6.10.1.1.1)
2 signifies transponder reporting a temporary alert condition (3.1.2.6.10.1.1.2)
3 signifies transponder reporting SPI condition (3.1.2.6.10.1.3)

Codes 1 and 2 shall take precedence over code 3.

3.1.2.8.6.3.1.2 *ACS, altitude code subfield in ME.* Under control of ATS (3.1.2.8.6.3.1.3), the transponder shall report either navigation-derived altitude, or the barometric altitude code in this 12-bit (41-52) subfield of ME when ME contains an airborne position message ~~report~~. When barometric altitude is reported, the contents of the ACS shall be as specified for the 13-bit AC field (3.1.2.6.5.4) except that the M-bit (bit 26) shall be omitted.

3.1.2.8.6.3.1.3 *Control of ACS reporting.* Transponder reporting of altitude data in ACS shall depend on the altitude type subfield (ATS) as specified in 3.1.2.8.6.8.2. Transponder insertion of barometric altitude data in the ACS subfield shall take place when the ATS subfield has the value of ZERO. Transponder insertion of barometric altitude data in ACS shall be inhibited when ATS has the value 1.

3.1.2.8.6.3.2 *Surface position squitter.* The surface position extended squitter type shall use format DF=17 with the contents of GICB register 06 {HEX} inserted in the ME field.

Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 6 will cause the resulting reply to contain the surface position message ~~report~~ in its MB field.

3.1.2.8.6.3.3 *Aircraft identification squitter.* The aircraft identification extended squitter type shall use format DF=17 with the contents of GICB register 08 {HEX} inserted in the ME field.

Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 8 will cause the resulting reply to contain the aircraft identification ~~report~~ message in its MB field.

3.1.2.8.6.3.4 *Airborne velocity squitter.* The airborne velocity extended squitter type shall use format DF=17 with the contents of GICB register 09 {HEX} inserted in the ME field.

Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 9 will cause the resulting reply to contain the airborne velocity ~~report~~ message in its MB field.

3.1.2.8.6.3.5 *Periodic status and event-driven squitters*

3.1.2.8.6.3.5.1 *Periodic status squitter.* The periodic status extended squitter types shall use format DF = 17 to convey aircraft status and other surveillance data. The aircraft operational status extended squitter type shall use the contents of GICB register 65 {HEX} inserted in the ME field. The target state and status extended squitter type shall use the contents of GICB register 62 {HEX} inserted in the ME field.

Note 1.— A GICB request (3.1.2.6.11.2) containing RR equals 22 and DI equals 3 or 7 and RRS equals 5 will cause the resulting reply to contain the aircraft operational status message in its MB field.

Note 2.— A GICB request (3.1.2.6.11.2) containing RR equals 22 and DI equals 3 or 7 and RRS equals 2 will cause the resulting reply to contain the target state and status information in its MB field.

3.1.2.8.6.3.5.2 *Event-driven squitter.* The event-driven extended squitter type shall use format DF=17 with the contents of GICB register 0A {HEX} inserted in the ME field.

Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 10 will cause the resulting reply to contain the event-driven ~~report~~ message in its MB field.

3.1.2.8.6.4 *Extended squitter rate*

3.1.2.8.6.4.1 *Initialization*. At power up initialization, the transponder shall commence operation in a mode in which it broadcasts only acquisition squitters (3.1.2.8.5). The transponder shall initiate the broadcast of extended squitters for airborne position, surface position, airborne velocity and aircraft identification when data are inserted into transponder registers 05, 06, 09 and 08 {HEX}, respectively. This determination shall be made individually for each squitter type. When extended squitters are broadcast, transmission rates shall be as indicated in the following paragraphs. Acquisition squitters shall be reported in addition to extended squitters unless the acquisition squitter is inhibited (2.1.5.4). Acquisition squitters shall always be reported if both position and ~~or~~ velocity extended squitters are not reported.

Note 1.— This suppresses the transmission of extended squitters from aircraft that are unable to report position, velocity or identity. If input to the register for ~~a~~ the position squitter type stops for 60 seconds, broadcast ~~of that extended squitter type~~ will be discontinued until data insertion is resumed. Broadcast of airborne position squitters is not discontinued if barometric altitude data is available. Terminating broadcast of other squitter types is described in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Note 2.— After timeout (3.1.2.8.6.6), ~~this~~ the position squitter type may contain an ME field of all zeroes.

3.1.2.8.6.4.2 *Airborne position squitter rate.* Airborne position squitter transmissions shall be emitted when the aircraft is airborne (3.1.2.8.6.7) at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous airborne position squitter, with the exceptions as specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.3 *Surface position squitter rate.* Surface position squitter transmissions shall be emitted when the aircraft is on the surface (3.1.2.8.6.7) using one of two rates depending upon whether the high or low squitter rate has been selected (3.1.2.8.6.9). When the high squitter rate has been selected, surface position squitters shall be emitted at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous surface position squitter (termed the high rate). When the low squitter rate has been selected, surface position squitters shall be emitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds using a time quantization of no greater than 15 milliseconds relative to the previous surface position squitter (termed the low rate). Exceptions to these transmission rates are specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.4 *Aircraft identification squitter rate.* Aircraft identification squitter transmissions shall be emitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds using a time quantization of no greater than 15 milliseconds relative to the previous identification squitter when the aircraft is reporting the airborne position squitter type, or when the aircraft is reporting the surface position squitter type and the high surface squitter rate has been selected. When the surface position squitter type is being reported at the low surface rate, the aircraft identification squitter shall be emitted at random intervals that are uniformly distributed over the range of 9.8 to 10.2 seconds using a time quantization of no greater than 15 milliseconds relative to the previous identification squitter. Exceptions to these transmission rates are specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.5 *Airborne velocity squitter rate.* Airborne velocity squitter transmissions shall be emitted when the aircraft is airborne (3.1.2.8.6.7) at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous airborne velocity squitter, with the exceptions as specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.6 *Periodic status and e~~E~~vent-driven squitter rates.*

3.1.2.8.6.4.6.1 P*eriodic status squitter rates.* The periodic status squitter types supported by a Mode S extended squitter transmitting system class, as specified in 5.1.1.2, shall be periodically emitted at defined intervals depending on the on-the-ground status and whether their content has changed.

Note.— The aircraft operational status extended squitter type and the target state and status extended squitter type rates are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.8.6.4.6.2 *Event-driven squitter rate.* The event-driven squitter shall be transmitted once, each time that GICB register 0A {HEX} is loaded, while observing the delay conditions specified in 3.1.2.8.6.4.7. The maximum transmission rate for the event-driven squitter shall be limited by the transponder to twice per second. If a message is inserted in the event-driven register and cannot be transmitted due to rate limiting, it shall be held and transmitted when the rate limiting condition has cleared. If a new message is received before transmission is permitted, it shall overwrite the earlier message.

~~*Note.— The squitter transmission rate and the duration of squitter transmissions is application-dependent. Choices made for each application must take into account interference considerations* as shown in the Aeronautical Surveillance Manual (Doc 9924).~~

3.1.2.8.6.4.7 *Delayed transmission.* Extended squitter transmission shall be delayed in the following circumstances:

a) if the transponder is in a transaction cycle (3.1.2.4.1);

b) if an acquisition or another type of extended squitter is in process; or

c) if a mutual suppression interface is active.

The delayed squitter shall be transmitted as soon as the transponder becomes available.

3.1.2.8.6.5 *Extended squitter antenna selection.* Transponders operating with antenna diversity (3.1.2.10.4) shall transmit extended squitters as follows:

a) when airborne (3.1.2.8.6.7), the transponder shall transmit each type of extended squitter alternately from the two antennas; and

b) when on the surface (3.1.2.8.6.7), the transponder shall transmit extended squitters under control of SAS (3.1.2.6.1.4.1 f)).

In the absence of any SAS commands, use of the top antenna only shall be the default condition.

3.1.2.8.6.6 *Register time-out and termination*. The transponder shall clear and terminate broadcast of ~~all 56-bits of the airborne position, surface position, and squitter status and airborne velocity~~ information in extended squitter ~~transponder~~ registers ~~05, 06, 07 and 097 {HEX} if these registers are not updated within two seconds of the previous update. This time-out shall be determined separately for each of these registers~~ as required to prevent the reporting of outdated information.

Note ~~1~~.— Timeout and termination of extended squitter broadcast is specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

~~*Note 2.— These registers are cleared to prevent the reporting of outdated position, velocity and squitter rate information.*~~

3.1.2.8.6.7 *Airborne/surface state determination.* Aircraft with an automatic means of determining on-the-ground conditions shall use this input to select whether to report the airborne or surface message types. Aircraft without such means shall report the airborne type messages, except as specified in Table 3-7. Use of this table shall only be applicable to aircraft that are equipped to provide data for radio altitude AND, as a minimum, airspeed OR ground speed. Otherwise, aircraft in the specified categories that are only equipped to provide data for airspeed and ground speed shall broadcast the surface format if:

airspeed < 50 knots AND ground speed < 50 knots

Aircraft with or without such automatic on-the-ground determination shall use position message types ~~set and report the on-the-ground status (and therefore broadcast the surface type format)~~ as commanded by control codes in TCS (3.1.2.6.1.4.1 f)). After time-out of the TCS commands, control of airborne/surface determination shall revert to the means described above.

Note 1. — Use of this technique may result in the surface position format being transmitted when the air-ground status in the CA fields indicates "airborne or on the ground".

Note 2.— Extended squitter ground stations determine aircraft airborne or on-the-ground status by monitoring aircraft position, altitude and ground speed. Aircraft determined to be on the ground that are not reporting the surface position message types ~~on-the-ground status~~ will be commanded to ~~set and~~ report the surface formats ~~on-the-ground status~~ via TCS (3.1.2.6.1.4.1 f)). The normal return to ~~aircraft control of the vertical status~~ the airborne position message types is via a ground command to ~~cancel the on-the-ground status~~ report airborne message types. To guard against loss of communications after take-off, commands to ~~set and~~ report the ~~on-the-ground status~~ surface position message types automatically time-out.

3.1.2.8.6.8 *Squitter status reporting.* A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 7 shall cause the resulting reply to contain the squitter status report in its MB field.

3.1.2.8.7 *EXTENDED SQUITTER/SUPPLEMENTARY, DOWNLINK FORMAT 18*

3.1.2.8.7.3 *ADS-B for extended squitter/non-transponder (ES/NT) devices*

. . .

3.1.2.8.7.3.2.4 *Airborne velocity squitter.* The airborne velocity type ES/NT shall use format DF=18 with the format for register 09 {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field.

3.1.2.8.7.3.2.5 *Periodic status and event-driven squitters.*

3.1.2.8.7.3.2.5.1 *Periodic status squitters.* The periodic status extended squitter types shall use format DF = 18 to convey aircraft status and other surveillance data. The aircraft operational status extended squitter type shall use the format of GICB register 65 {HEX} as defined in 3.1.2.8.6.4.6.1 inserted in the ME field. The target state and status extended squitter type shall use the format of GICB register 62 {HEX} as defined in 3.1.2.8.6.4.6.1 inserted in the ME field.

3.1.2.8.7.3.2.5.2 *Event-driven squitter.* The event-driven type ES/NT shall use format DF=18 with the format for register 0A {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field.

3.1.2.8.7.3.3 *ES/NT squitter rate*

3.1.2.8.7.3.3.1 *Initialization.* At power up initialization, the non-transponder device shall commence operation in a mode in which it does not broadcast any squitters. The non-transponder device shall initiate the broadcast of ES/NT squitters for airborne position, surface position, airborne velocity and aircraft identification when data are available for inclusion in the ME field of these squitter types. This determination shall be made individually for each squitter type. When ES/NT squitters are broadcast, transmission rates shall be as indicated in 3.1.2.8.6.4.2 to 3.1.2.8.6.4.6.

Note 1.— This suppresses the transmission of extended squitters from aircraft that are unable to report position, velocity or identity. If input to the register for the position squitter type~~s~~ stops for 60 seconds, broadcast ~~for this extended squitter type~~ will cease until data insertion resumes, except for an ES/NT device operating on the surface (as specified ~~for extended squitter Version 1 formats~~ in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871)). Broadcast of airborne position squitters is not discontinued if barometric altitude data is available. Terminating broadcast of other squitter types is described in Doc 9871.*

Note 2.— After timeout (3.1.2.8.7.6) this squitter type may contain an ME field of all zeros.

3.1.2.8.7.3.3.2 *Delayed transmission.* ES/NT squitter transmission shall be delayed if the non-transponder device is busy broadcasting one of the other squitter types.

3.1.2.8.7.3.3.2.1 The delayed squitter shall be transmitted as soon as the non-transponder device becomes available.

3.1.2.8.7.3.3.3 *ES/NT antenna selection.* Non-transponder devices operating with antenna diversity (3.1.2.10.4) shall transmit ES/NT squitters as follows:

a) when airborne (3.1.2.8.6.7), the non-transponder device shall transmit each type of ES/NT squitter alternately from the two antennas; and

b) when on the surface (3.1.2.8.6.7), the non-transponder device shall transmit ES/NT squitters using the top antenna.

3.1.2.8.7.3.3.4 *Register timeout and termination.* The non-transponder device shall clear message fields and terminate broadcast of ~~all 56-bits of the airborne position, and surface position and velocity registers~~ extended squitter messages ~~used for these messages if these registers are not updated within two seconds of the previous update. This timeout shall be determined separately for each of these registers~~ as required to prevent the reporting of outdated information.

Note 1.— The timeout and termination of an extended squitter broadcast is specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

~~*Note 2.— These registers are cleared to prevent the reporting of outdated position and velocity information.*~~

3.1.2.8.7.3.3.5 *Airborne/surface state determination.* Aircraft with an automatic means of determining the on-the-ground state shall use this input to select whether to report the airborne or surface message types except as specified in 3.1.2.6.10.3.1~~ and 3.1.2.8.6.7~~. Aircraft without such means shall report the airborne type message~~, except as specified in 3.1.2.8.6.7~~.

3.1.2.8.7.3.3.6 *Surface squitter rate control.* Aircraft motion shall be determined once per second. The surface squitter rate shall be set according to the results of this determination.

Note.— The algorithm to determine aircraft motion is specified in the definition of register 07_{16} in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

…

3.1.2.8.7.4 *Use of ES by other surveillance systems.*

3.1.2.8.7.4.1 *Surface system control.*

Recommendation.— *When a surface surveillance system uses DF=18 as part of a surveillance function, it should not use the formats that have been allocated for the purpose of surveillance of aircraft, vehicles and/or obstacles.*

Note 1.— The formats allocated for the purpose of surveillance of aircraft, vehicles and/or obstacles are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Note 2.— The transmission of any message format used for conveying position, velocity, identification, state information, etc. may result in the initiation and maintenance of false tracks in other 1090ES receivers. The use of these messages for this purpose may be prohibited in the future.

3.1.2.8.7.4.2 *Surface system status.*

Recommendation.— *The surface system status message type (Type Code=24) should be the only message used to provide the status or synchronization of surface surveillance systems.*

Note.— The surface system status message is specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). This message will be used only by the surface surveillance system that generated it and will be ignored by other surface systems.*

3.1.2.8.9 *EXTENDED SQUITTER MAXIMUM TRANSMISSION RATE*

3.1.2.8.9.1 The maximum total number of full power extended squitters (DF = 17, 18 and 19) emitted by any extended squitter installation shall not exceed ~~6.2 per second, except as specified in 3.1.2.8.9.2.~~ the following:

a) 6.2 messages per second averaged over 60 seconds for nominal aircraft operations with no emergency and no ACAS RA activity, while not exceeding 11 messages being transmitted in any 1-second interval; or

b) 7.4 messages per second averaged over 60 seconds under an emergency and/or ACAS RA condition, while not exceeding 11 messages being transmitted in any 1-second interval.

…

3.1.2.10 ESSENTIAL SYSTEM CHARACTERISTICS OF THE SSR MODE S TRANSPONDER

3.1.2.10.1 *Transponder sensitivity and dynamic range.* Transponder sensitivity shall be defined in terms of a given interrogation signal input level and a given percentage of corresponding replies. Only correct replies containing the required bit pattern for the interrogation received shall be counted. Given an interrogation that requires a reply according to 3.1.2.4, the minimum triggering level, MTL, shall be defined as the minimum input power level for 90 per cent reply-to-interrogation ratio. The MTL shall be –74 dBm ±3 dB for Mode S interrogations (interrogations using P6), and as defined in 3.1.1.7.5.1 b for Mode A and C, and inter-mode interrogations. The reply-to-interrogation ratio of a Mode S transponder shall be:

…

3.1.2.10.3.10.2 **Recommendation.**— *Mode A/C replies should be inhibited when the aircraft is on the ground to prevent interference when in close proximity to an interrogator or other aircraft.*

Note.— Mode S discretely addressed interrogations do not give rise to such interference and may be required for data link communications with aircraft on the airport surface. Acquisition squitter transmissions may be used for passive surveillance of aircraft on the airport surface.

~~3.1.2.10.3.10.3 *Inhibition of squitter transmissions.* It shall not be possible to inhibit extended squitter transmissions except as specified in 3.1.2.8.6 or acquisition squitter transmissions except as specified in 3.1.2.8.5 regardless of whether the aircraft is airborne or on the ground.~~

~~*Note.— For additional information on squitter inhibition see the* Aeronautical Surveillance Manual *(Doc 9924).*~~

3.1.2.10.4 *Transponder antenna system and diversity operation.* Mode S transponders equipped for diversity operation shall have two RF ports for operation with two antennas, one antenna on the top and the other on the bottom of the aircraft's fuselage. The received signal from one of the antennas shall be selected for acceptance and the reply shall be transmitted from the selected antenna only.

3.1.2.10.5 *DATA PROCESSING AND INTERFACES*

…

3.1.2.10.5.1.4 *Interfaces for variable direct data.*

3.1.2.10.5.1.4.1 A means shall be provided, while on the ground or during flight, for the ~~Mode A identity code, the~~ SPI condition ~~and, for transponders of Level 2 and above, the aircraft identification to be inserted by the pilot via a variable data interface~~ to be inserted by the pilot, without the entry or modification of other flight data.

3.1.2.10.5.1.4.2 A means shall be provided, while on the ground or during flight, for the Mode A identity code to be displayed to the pilot and modified without the entry or modification of other flight data.

3.1.2.10.5.1.4.3 For transponders of Level 2 and above, a means shall be provided, while on the ground or during flight, for the aircraft identification to be displayed to the pilot, and, when containing variable data (3.1.2.10.5.1.3 d), to be modified without the entry or modification of other flight data.

Note.— Implementation of the pilot action for entry of data will be as simple and efficient as possible in order to minimize the time required and reduce the possibility of errors in the data entry.

3.1.2.10.5.1.4.4 Interfaces shall be included to accept the pressure-altitude and on-the-ground coding.

Note.— A specific interface design for the variable direct data is not prescribed.

…

3.1.2.11 ESSENTIAL SYSTEM CHARACTERISTICS OF THE GROUND INTERROGATOR

3.1.2.11.1.1 *All-call interrogation repetition rate.*

3.1.2.11.1.1.1 The interrogation repetition rate for the Mode A/C/S all-call, used for acquisition, shall be less than 250 per second. This rate shall also apply to the paired Mode S-only and Mode A/C-only all-call interrogations used for acquisition in the multisite mode.

3.1.2.11.1.1.2 *Maximum number of Mode S all-call replies triggered by an interrogator.* For aircraft that are not locked out, a Mode S interrogator shall not trigger, on average, more than 6 all-call replies per period of 200 ms and no more than 26 all call replies counted over a period of 18 seconds.

TABLES FOR CHAPTER 3

Table 3-3. Field definitions

➔ Insert/Add the following entry:

Field		*Format*		*Reference*
Designator	*Function*	*UF*	*DF*	
DP	Data parity		20, 21	3.1.2.3.2.1.5

Table 3-4. Subfield definitions

➔ Insert/Add the following entry:

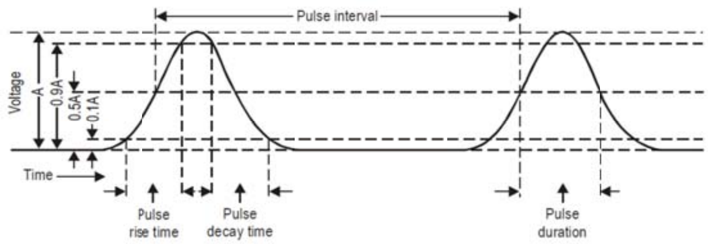
Subfield			
Designator	*Function*	*Field*	*Reference*
MES	Multisite ELM subfield	SD	3.1.2.6.1.4.1.c)
OVC	Overlay control	SD	3.1.2.6.1.4.1.i)
RCS	Rate control subfield	SD	3.1.2.6.1.4.1.f)

Table 3-6. Table for register 10_{16}

➔ Insert/Add the following entry:

Subfields of register 10_{16}	*MB bits*	*Comm-B bits*
Continuation flag	9	41
Overlay command capability	15	47
ACAS capability	16 and 37 - 40	48 and 69 - 72

FIGURES FOR CHAPTER 3



Definitions

Phase reversal. A 180-degree change in the phase of the radio frequency carrier.

Phase reversal duration. The time between the 10-degree and 170-degree points of a phase reversal.

Pulse amplitude A. The peak voltage amplitude of the pulse envelope.

Pulse decay time. The time between 0.9A and 0.1A on the trailing edge of the pulse envelope.

Pulse duration. The time interval between 0.5A points on leading and trailing edges of the pulse envelope.

Pulse interval. The time interval between the 0.5A point on the leading edge of the first pulse and the 0.5A point on the leading edge of the second pulse.

Pulse rise time. The time between 0.1A and 0.9A on the leading edge of the pulse envelope.

Time intervals. The intervals are referenced to:

a) the 0.5A point on the leading edge of a pulse;

b) the 0.5A point on the trailing edge of a pulse; or

c) the 90-degree point of a phase reversal.

Transponder sensitivity and power reference point. The antenna end of the transmission line of the transponder.

~~*Note.— The 90 degree point of a phase reversal can be approximated by the minimum amplitude point on the envelope amplitude transient associated with the phase reversal and the phase reversal duration can be approximated by the time between the 0.8A points of the envelope amplitude transient.*~~

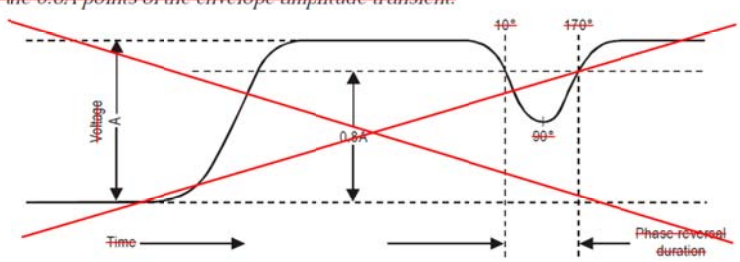


Figure 3-1. Definitions of secondary surveillance radar waveform shapes, intervals and the reference point for sensitivity and power

a. Change Figure 3-8 such that DF=20 and DF=21 appear as follows:

20	**10100**	**FS:3**	**DR:5**	**UM:6**	**AC:13**	**MB:56**	**AP:24** / **DP:24**	**. . . Comm-B, Altitude reply (see Note 5)**
21	**10101**	**FS :3**	**DR :5**	**UM :6**	**ID :13**	**MB :56**	**AP:24** / **DP:24**	**. . . Comm-B, Identity reply (see Note 5)**

b. Add Note 5 to Figure 3-8 as follows:

5. The Data parity (DP) (3.1.2.3.2.1.5) is used if it has been commanded by the OVC (3.1.2.6.1.4.1.i) in accordance with paragraph 3.1.2.6.11.2.5.

CHAPTER 4. AIRBORNE COLLISION AVOIDANCE SYSTEM

…

4.3.8.4.2 *ACAS FIELDS AND SUBFIELDS*

…

4.3.8.4.2.2.2 *Subfields in MB for the data link capability report.* When BDS1 = 1 and BDS2 = 0, the following bit patterns shall be provided to the transponder for its data link capability report:

Bit	*Coding*
48	0 ACAS failed or on standby
	1 ACAS operating
69	0 Hybrid surveillance not operational
	1 Hybrid surveillance fitted and operational
70	0 ACAS generating TAs only
	1 ACAS generating TAs and RAs

Bit 72	Bit 71	ACAS version
0	0	RTCA/DO-185 (pre-ACAS)
0	1	RTCA/DO-185A
1	0	RTCA/DO-185B & EUROCAE ED 143
1	1	Reserved for ~~F~~future versions (see Note 3 ~~registers $E5_{16}$ and $E6_{16}$~~)

Note 1.— A summary of the MB subfields for the data link capability report structure is described in Chapter 3, 3.1.2.6.10.2.2.

Note 2.— The use of hybrid surveillance to limit ACAS active interrogations is described in 4.5.1. The ability only to support decoding of DF = 17 extended squitter messages is not sufficient to set bit 72.

Note 3.— Future versions of ACAS will be identified using part numbers and software version numbers specified in registers $E5_{16}$ and $E6_{16}$.

…

CHAPTER 5. MODE S EXTENDED SQUITTER

…

5.1.1 ADS-B OUT requirements

5.1.1.1 Aircraft, surface vehicles and fixed obstacles supporting an ADS-B capability shall incorporate the ADS-B message generation function and the ADS-B message exchange function (transmit) as depicted in Figure 5-1.

5.1.1.1.1 ADS-B transmissions from aircraft shall include position, aircraft identification and type, airborne velocity, periodic status and event driven messages including emergency/priority information.

5.1.1.1.2 **Recommendation.**— *Extended squitter transmitting equipment should use formats and protocols of the latest version available.*

Note 1.— The data formats and protocols for messages transferred via extended squitter are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Note 2.— Some States and/or regions require extended squitter version 2 to be transmitted by specific dates.

5.1.1.2 *Extended squitter ADS-B transmission requirements.* Mode S extended squitter transmitting equipment shall be classified according to the unit's range capability and the set of parameters that it is capable of transmitting consistent with the following definition of general equipment classes and the specific equipment classes defined in Tables 5-1 and 5-2:

…

5.1.1.4 *Control of ADS-B OUT operation.*

5.1.1.4.1 **Recommendation.** — *Protection against reception of corrupted data from the source providing the position should be satisfied by error detection on the data inputs and the appropriate maintenance of the installation.*

5.1.1.4.2 If an independent control of the ADS-B OUT function is provided, then the operational state of the ADS-B OUT function shall be indicated to the flight crew, at all times.

Note.— There is no requirement for an independent control for the ADS-B OUT function.

5.2 MODE S EXTENDED SQUITTER RECEIVING SYSTEM CHARACTERISTICS (ADS-B IN AND TIS-B IN)

Note 1.— The paragraphs herein describe the required capabilities for 1 090 MHz receivers used for the reception of Mode S extended squitter transmissions that convey ADS-B and/or TIS-B messages. Airborne receiving systems support ADS-B and TIS-B reception while ground receiving systems support only ADS-B reception.

Note 2.— Detailed technical provisions for Mode S extended squitter receivers can be found within RTCA DO-260~~A~~B/EUROCAE ED-102A, "Minimum Operational Performance Standards for 1 090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)."

5.2.1 Mode S extended squitter receiving system functional requirements

…

5.2.1.2 *Mode S extended squitter receiver classes*. The required functionality and performance characteristics for the Mode S extended squitter receiving system will vary depending on the ADS-B and TIS-B client applications to be supported and the operational use of the system. Airborne Mode S extended squitter receivers shall be consistent with the definition of receiving system classes shown in Table 5-3.

Note.— Different equipment classes of Mode S extended squitter installations are possible. The characteristics of the receiver associated with a given equipment class are intended to be appropriate to support the required level of operational capability. Equipment classes A0 through A3 are applicable to those Mode S extended airborne installations that include a Mode S extended squitter transmission (ADS-OUT) and reception (ADS-B IN) capability. Equipment classes B0 through B3 are applicable to Mode S extended installations with only a transmission (ADS-B OUT) capability and includes equipment classes applicable to airborne, surface vehicles and fixed obstructions. Equipment classes C1 through C3 are applicable to Mode S extended squitter ground receiving systems. ~~*Guidance on the Mode S extended squitter equipment classes is provided in the* Manual on the Secondary Surveillance Radar (SSR) Systems *(Doc 9684).*~~

5.2.2 Message exchange function

…

5.2.2.4 *Enhanced reception techniques.* Class A1, A2 and A3 airborne receiving systems shall include the following features to provide improved probability of Mode S extended squitter reception in the presence of multiple overlapping Mode A/C fruit and/or in the presence of an overlapping stronger Mode S fruit, as compared to the performance of the standard reception technique required for Class A0 airborne receiving systems:

a) Improved Mode S extended squitter preamble detection.

b) Enhanced error detection and correction.

c) Enhanced bit and confidence declaration techniques applied to the airborne receiver classes as shown below:

   1) Class A1 – Performance equivalent to or better than the use of the "Centre Amplitude" technique.

   2) Class A2 – Performance equivalent to or better than the use of the "Multiple Amplitude Samples" baseline technique, where at least 8 samples are taken for each Mode S bit position and are used in the decision process.

   3) Class A3 – Performance equivalent to or better than the use of the "Multiple Amplitude Samples" baseline technique, where at least 10 samples are taken for each Mode S bit position and are used in the decision process.

Note 1.— The above enhanced reception techniques are as defined in RTCA DO-260~~A~~B/EUROCAE ED-102A, Appendix I.

Note 2.— The performance provided for each of the above enhanced reception techniques when used in a high fruit environment (i.e. with multiple overlapping Mode A/C fruit) is expected to be at least equivalent to that provided by the use of the techniques described in RTCA DO-260~~A~~B/EUROCAE ED-102A, Appendix I.

Note 3.— It is considered appropriate for ground extended squitter receiving systems to employ the enhanced reception techniques equivalent to those specified for airborne Class A2 or A3 receiving systems.

…

5.2.3.3 ADS-B REPORT TYPES

Note 1.— The ADS-B report refers to the restructuring of ADS-B message data received from Mode S extended squitter broadcasts into various reports that can be used directly by a set of client applications. Five ADS-B report types are defined by the following subparagraphs for output to client applications. Additional information on the ADS-B report contents and the applicable mapping from extended squitter messages to ADS-B reports can be found in the ~~Manual on the Secondary Surveillance Radar (SSR) Systems~~ ~~*(Doc 9684) and RTCA DO-260A*~~ Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871) and RTCA DO-260B / EUROCAE ED-102A.*

Note 2.— The use of precision (e.g. GNSS UTC measured time) versus non-precision (e.g. internal receiving system clock) time sources as the basis for the reported time of applicability is described in 5.2.3.5.

5.2.3.3.1 *State vector report.* The state vector report shall contain time of applicability, information about an airborne or vehicle's current kinematic state (e.g. position, velocity), as well as a measure of the integrity of the navigation data, based on information received in airborne or ground position, airborne velocity,~~ and~~ identification and ~~type~~ category, aircraft operational status and target state and status extended squitter messages. Since separate messages are used for position and velocity, the time of applicability shall be reported individually for the position related report parameters and the velocity related report parameters. Also, the state vector report shall include a time of applicability for the estimated position and/or estimated velocity information (i.e. not based on a message with updated position or velocity information) when such estimated position and/or velocity information is included in the state vector report.

Note.— Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant (ground or airborne). The state vector data is the most dynamic of the four ADS-B reports; hence, the applications require frequent updates of the state vector to meet the required accuracy for the operational dynamics of the typical airborne or ground operations of airborne and surface vehicles.

5.2.3.3.2 *Mode status report.* The mode status report shall contain time of applicability and current operational information about the transmitting participant, including airborne/vehicle address, call sign, ADS-B version number, airborne/vehicle length and width information, state vector quality information, and other information based on information received in aircraft operational status, target state and status, ~~airborne~~ aircraft identification and ~~type~~ category, airborne velocity and ~~airborne~~ aircraft status extended squitter messages. Each time that a mode status report is generated, the report assembler function shall update the report time of applicability. Parameters for which valid data is not available shall either be indicated as invalid or omitted from the mode status report.

Note 1.— Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant (ground or airborne).

~~*Note 2.— Once the target state and status message (as shown in the* Manual on Mode S Specific Services *(Doc 9688)) becomes available, certain parameters conveyed in that message type are also to be included in the mode status reports.*~~

Note ~~3~~2.— The age of the information being reported within the various data elements of a mode status report may vary as a result of the information having been received within different extended squitter messages at different times. ~~*Data being reported beyond the useful life of that parameter type may be either indicated as invalid or omitted from the mode status report as described in the* Manual on the Secondary Surveillance Radar (SSR) Systems *(Doc 9684).*~~

5.2.3.3.3 *Air referenced velocity report.* Air referenced velocity reports shall be generated when air referenced velocity information is received in airborne velocity extended squitter messages. The air referenced velocity report shall contain time of applicability, airspeed and heading information. Only certain classes of extended squitter receiving systems, as defined in 5.2.3.5, are required to generate air referenced velocity reports. Each time that an individual mode status report is generated, the report assembly function shall update the report time of applicability.

Note 1.— The air referenced velocity report contains velocity information that is received in airborne velocity messages along with additional information received in airborne identification and ~~type~~ category extended squitter messages. Air referenced velocity reports are not generated when ground referenced velocity information is being received in the airborne velocity extended squitter messages. ~~*Guidance on the air referenced velocity report contents is provided in the* Manual on the Secondary Surveillance Radar (SSR) Systems *(Doc 9684).*~~

Note 2.— Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant (ground or airborne).

5.2.3.3.4 *Resolution advisory (RA) report.* The RA report shall contain time of applicability and the contents of an active ACAS resolution advisory (RA) as received in a Type=28 and Subtype=2 extended squitter message.

Note.— The RA report is only intended to be generated by ground receiving subsystems when supporting a ground ADS-B client application(s) requiring active RA information. An RA report will nominally be generated each time a Type=28, Subtype=2 extended squitter message is received.

5.2.3.3.5 TARGET STATE REPORT

Note.— ~~The requirements for reporting of target state information is not at the same level of maturity as for the other ADS-B report types. The reporting of target state information is currently not required, but may in the future be required for Class A2 and A3 airborne receiving systems. Once supported, t~~ The target state report will be generated when information is received in target state and status messages, along with additional information received in airborne identification and ~~type~~ category extended squitter messages. The target state and status message is defined in the ~~Manual on Mode S Specific Services *(Doc 9688).*~~ Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant (ground or airborne). ~~Guidance on the target state report contents is provided in the~~* ~~Manual on Mode S Specific Services *(Doc 9688).*~~

5.2.3.4 TIS-B REPORT TYPES

5.2.3.4.1 As TIS-B messages are received by airborne receiving systems, the information shall be reported to client applications. Each time that an individual TIS-B report is generated, the report assembly function shall update the report time of applicability to the current time.

Note 1.— The TIS-B message formats are defined in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Note 2.— The TIS-B report refers to the restructuring of TIS-B message data received from ground Mode S extended squitter broadcasts into reports that can be used by a set of client applications. Two ADS-B report types are defined by the following subparagraphs for output to client applications. Additional information on the TIS-B report contents and the applicable mapping from extended squitter messages to ADS-B reports can be found in the ~~Manual on the Secondary Surveillance Radar (SSR) Systems *(Doc 9684)*~~ Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Note 3.— The use of precision (e.g. GNSS UTC measured time) versus non-precision (e.g. internal receiving system clock) time sources as the basis for the reported time of applicability is described in 5.2.3.5.

…

5.2.3.4.5.1 The contents of any received TIS-B management message shall be reported bit-for-bit to the client applications.

~~*Note.— The processing of TIS-B management messages is defined in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*~~

5.2.3.5 REPORT TIME OF APPLICABILITY

The receiving system shall use a local source of reference time as the basis for reporting the time of applicability, as defined for each specific ADS-B and TIS-B report type (see 5.2.3.3 and 5.2.3.4).

5.2.3.5.1 *Precision time reference.* Receiving systems intended to generate ADS-B and/or TIS-B reports based on the reception of surface position messages, airborne position messages, and/or TIS-B messages shall use GNSS UTC measured time for the purpose of generating the report time applicability for the following cases of received messages:

a) version zero (0) ADS-B messages, as defined in 3.1.2.8.6.2, when the navigation uncertainty category (NUC) is 8 or 9; or

b) version one (1) or version two (2) ADS-B or TIS-B messages, as defined in 3.1.2.8.6.2 and 3.1.2.8.7 respectively, when the navigation integrity category (NIC) is 10 or 11;

UTC measured time data shall have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

…

5.2.4 Interoperability

The Mode S extended squitter receiving system shall provide interoperability between the different versions of ~~with both version 0 and version 1~~ extended squitter ADS-B message formats.

Note 1.— ~~Version 0 and version 1~~ All defined ADS-B versions and their corresponding message formats are ~~defined~~ contained in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871) and are identified by a version number.*

Note 2.— ADS-B message formats are defined with backward compatibility with previous versions. An extended squitter receiver can recognize and decode signals of its own version, as well as the message formats from lower versions. The receiver, however, can decode the portion of messages received from a higher version transponder according to its own capability.

~~*Note 2.— Techniques for providing interoperability of version 0 and version 1 ADS-B message formats are described in the* Manual on the Secondary Surveillance Radar (SSR) Systems *(Doc 9684) and further information is provided in RTCA DO-260A, Appendix N.*~~

5.2.4.1 INITIAL MESSAGE DECODING

The Mode S extended squitter receiving system shall, upon acquiring a new ADS-B target, initially apply the decoding provisions applicable to version 0 (zero) ADS-B messages until or unless an aircraft operational status message is received indicating ~~version 1 (one),~~ that a higher version message format is in use.

5.2.4.2 APPLYING VERSION NUMBER

The Mode S extended squitter receiving system shall decode the version number information conveyed in the aircraft operational status message and shall apply the corresponding decoding rules~~, version 0 (zero) or version 1 (one),~~ for the reported version, up to the highest version supported by the receiving system, for the decoding of the subsequent extended squitter ADS-B messages from that specific ~~airborne~~ aircraft or vehicle.

TABLES FOR CHAPTER 5

Table 5-1. ADS-B Class A equipment characteristics

Equipment class	*Minimum transmit power (at antenna terminal)*	*Maximum transmit power (at antenna terminal)*	*Airborne or surface*	*Minimum extended squitter message capability required (see Note 2)*
A0 (Minimum)	18.5 dBW (see Note 1)	27 dBW	Airborne	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category Airborne velocity ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
			Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
A1 (Basic)	21 dBW	27 dBW	Airborne	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category Airborne velocity ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
			Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
A2 (Enhanced)	21 dBW	27 dBW	Airborne	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category Airborne velocity ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status ~~Reserved for target~~ Target state and status
			Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
A3 (Extended)	23 dBW	27 dBW	Airborne	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category Airborne velocity ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status ~~Reserved for target~~ Target state and status
			Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status

Note 1.— See Chapter 3, 3.1.2.10.2 for restrictions on the use of this category of Mode S transponder.

Note 2.— The extended squitter messages applicable to Class A equipment are defined in ~~Version 1 of extended squitter formats of~~ the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Table 5-2. ADS-B Class B equipment characteristics

Equipment class	*Minimum transmit power (at antenna terminal)*	*Maximum transmit power (at antenna terminal)*	*Airborne or surface*	*Minimum extended squitter message capability required*
B0 (Airborne)	18.5 dBW (see Note 1)	27 dBW	Airborne	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category Airborne velocity ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
			Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
B1 (Airborne)	21 dBW	27 dBW	Airborne	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category Airborne velocity ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
			Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status Extended squitter ~~A/C~~ aircraft status
B2 Low (Ground Vehicle)	8.5 dBW	< 18.5 dBW (see Note 2)	Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status
B2 (Ground Vehicle)	18.5 dBW	27 dBW (see Note 2)	Surface	Surface position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status
B3 (Fixed Obstacle)	18.5 dBW	27 dBW (see Note 2)	Airborne (see Note 3)	Airborne position ~~A/C~~ Aircraft identification and ~~type~~category ~~A/C~~ Aircraft operational status

Note 1.— See Chapter 3, 3.1.2.10.2 for restrictions on the use of this category of Mode S transponder.

Note 2.— The appropriate ATS authority is expected to get the maximum power level permitted.

Note 3.— Fixed obstacles use the airborne ADS-B message formats since knowledge of their location is of primary interest to airborne aircraft.

Table 5-3. Reception performance for airborne receiving systems

Receiver class	*Intended air-to-air operational range*	*Receiver minimum trigger threshold level (MTL) (see Note 1)*	*Reception Technique (see Note 2)*	*Required extended squitter ADS-B message support* ~~*(see Note 3)*~~	*Required extended squitter TIS-B message support* ~~*(see Note 4)*~~
A0 (Basic VFR)	10 ~~nmi.~~ NM	–72 dBm ~~(see Note 1)~~	Standard ~~(See Note 2)~~	Airborne position Surface position Airborne velocity ~~Airborne~~Aircraft identification and ~~type~~category Extended squitter airborne status ~~Airborne~~ Aircraft operational status	Fine airborne position Coarse airborne position Fine surface position Aircraft Identification and ~~type~~category Airborne velocity Management
A1 (Basic IFR)	20 ~~nmi.~~ NM	–79 dBm ~~(see Note 1)~~	Enhanced ~~(See Note 2)~~	Airborne position Surface position Airborne velocity ~~Airborne~~Aircraft identification and ~~type~~category Extended squitter airborne status ~~Airborne~~ Aircraft operational status	Fine airborne position Coarse airborne position Fine surface position Aircraft Identification and ~~type~~category Airborne velocity Management
A2 (Enhanced IFR)	40 ~~nmi.~~ NM	–79 dBm ~~(see Note 1)~~	Enhanced ~~(See Note 2)~~	Airborne position Surface position Airborne velocity ~~Airborne~~Aircraft identification and ~~type~~category Extended squitter airborne status ~~Airborne~~ Aircraft operational status ~~Reserved for target~~ Target state and status	Fine airborne position Coarse airborne position Fine surface position Aircraft Identification and ~~type~~category Airborne velocity Management
A3 (Extended capability)	90 ~~nmi.~~ NM	–84 dBm (and -87 dBm at 15% probability of reception – ~~see Note 1~~)	Enhanced ~~(See Note 2)~~	Airborne position Surface position Airborne velocity ~~Airborne~~Aircraft identification and ~~type~~category Extended squitter airborne status ~~Airborne~~ Aircraft operational status ~~Reserved for target~~ Target state and status	Fine airborne position Coarse airborne position Fine surface position Aircraft Identification and ~~type~~category Airborne velocity Management

Note 1.— Specific MTL is referenced to the signal level at the output terminal of the antenna, assuming a passive antenna. If electronic amplification is integrated into the antenna assembly, then the MTL is referenced at the input to the amplifier. For Class A3 receivers, a second performance level is defined at a received signal level of –87 dBm where 15 per cent of the messages are to be successfully received. MTL values refer to reception under non-interference conditions.

Note 2.— The extended squitter receiver reception techniques are defined in 5.2.2.4. "Standard" reception techniques refer to the baseline techniques, as required for ACAS 1 090 MHz receivers, that are intended to handle single overlapping Mode A/C fruit. "Enhanced" reception techniques refer to techniques intended to provide improved reception performance in the presence of multiple overlapping Mode A/C fruit and improved decoder re-triggering in the presence of overlapping stronger Mode S fruit. The requirements for the enhanced reception techniques that are applicable to the specific airborne receiver classes are defined in 5.2.2.4.

~~*Note 3.— The extended squitter messages are defined in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). However, the target state and status message, as defined in the* Manual on Mode S Specific Services *(Doc 9688), is not yet at the same level of maturity as the other ADS-B messages.*~~

~~*Note 4.— The TIS-B messages are defined in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*~~

Table 5-4. Mode S extended squitter airborne receiving system reporting requirements

Receiver class	*Minimum ADS-B reporting requirements*	*Minimum TIS-B reporting requirements*
A0 (Basic VFR)	ADS-B state vector report (per 5.2.3.~~1~~3.1) and ADS-B mode status report (per 5.2.3.~~1~~3.2)	TIS-B state report and TIS-B management report
A1 (Basic IFR)	ADS-B state vector report (per 5.2.3.~~1~~3.1) and ADS-B mode status report (per 5.2.3.~~1~~3.2) and ADS-B air referenced velocity report (ARV) (per 5.2.3.~~1~~3.3)	TIS-B state report and TIS-B management report
A2 (Enhanced IFR)	ADS-B state vector report (per 5.2.3.~~1~~3.1) and ADS-B mode status report (per 5.2.3.~~1~~3.2) and ADS-B ARV report (per 5.2.3.~~1~~3.3) and ~~Reserved for~~ ADS-B target state report (per 5.2.3.~~1.4~~3.5)	TIS-B state report and TIS-B management report
A3 (Extended capability)	ADS-B state vector report (per 5.2.3.~~1~~3.1) and ADS-B mode status report (per 5.2.3.~~1~~3.2) and ADS-B ARV report (per 5.2.3.~~1~~3.3) and ~~Reserved for~~ ADS-B target state report (per 5.2.3.~~1.4~~3.5)	TIS-B state report and TIS-B management report

CHAPTER 6. MULTILATERATION SYSTEMS

6.3 PROTECTION OF THE RADIO FREQUENCY ENVIRONMENT

Note.— This section only applies to active MLAT systems.

6.3.1 In order to minimize system interferences the effective radiated power of active interrogators shall be reduced to the lowest value consistent with the operationally required range of each individual interrogator site.

Note.— Guidance material on power consideration is contained in the Aeronautical Surveillance Manual (Doc 9924).

6.3.2 An active MLAT system shall not use active interrogations to obtain information that can be obtained by passive reception within each required update period.

Note.— Transponder occupancy will be increased by the use of omnidirectional antennas. It is particularly significant for Mode S selective interrogations because of their higher transmission rate. All Mode S transponders will be occupied decoding each selective interrogation not just the addressed transponder.

6.3.3 An active MLAT system consisting of a set of transmitters shall be considered as a single Mode S interrogator.

6.3.~~3~~4 The set of transmitters used by all active MLAT systems in any part of the airspace shall not ~~occupy any transponder more than 2 per cent of the time~~ cause any transponder to be impacted such that its occupancy, because of the aggregate of all MLAT 1030 MHz interrogations, is greater than 2 per cent at any time.

Note 1.— This represents a minimum requirement. Some regions may impose stricter requirements.

Note 2.— ~~The use of active MLAT systems may be even more restrictive in some regions.~~ For an MLAT system using only Mode S interrogations, 2 per cent is equivalent to no more than 400 Mode S interrogations per second received by any aircraft from all systems using MLAT technology.

6.3.~~4~~5 Active MLAT systems shall not use Mode S All-Call interrogations.

Note.— Mode S aircraft can be acquired by the reception of acquisition squitter or extended squitter even in airspace where there are no active interrogators.

~~ATTACHMENT TO VOLUME IV~~
~~Guidance material related to~~
~~airborne collision avoidance system (ACAS)~~

Editorial Note.— Delete all the remaining pages of the Attachment to Volume IV.

— END —

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منظمة الطيران
المدني الدولي

国际民用
航空组织

Tel.: +1 514-954-8219, ext. 6712

Ref.: AN 7/1.3.102-14/36 30 April 2014

Subject: Proposals for the amendment of Annex 10, Volume I, concerning the global navigation satellite system (GNSS)

Action required: Comments to reach Montréal by 31 July 2014

Sir/Madam,

1. I have the honour to inform you that the Air Navigation Commission, at the eighth meeting of its 195th Session held on 6 March 2014, considered proposals developed by the Navigation Systems Panel (NSP) Working Group of the Whole to amend the Standards and Recommended Practices (SARPs) in Annex 10 — *Aeronautical Telecommunications*, Volume I — *Radio Navigation Aids* concerning the global navigation satellite system (GNSS). The Commission authorized their transmission to Member States and appropriate international organizations for comments.

2. Background information on elements of the proposal is included for your convenience in Attachment A. The proposed amendments, as modified by the Air Navigation Commission, are contained in Attachment B, and their rationales are contained in Attachment C.

3. It should be noted that minimal financial impact is anticipated from the proposed changes.

4. In examining the proposed amendments, you should not feel obliged to comment on editorial aspects as such matters will be addressed by the Air Navigation Commission during its final review of the draft amendment.

5. May I request that any comments you may wish to make on the amendment proposals be dispatched to reach me not later than 31 July 2014. The Air Navigation Commission has asked me to specifically indicate that comments received after the due date may not be considered by the Commission and the Council. In this connection, should you anticipate a delay in the receipt of your reply, please let me know in advance of the due date.

999 University Street
Montréal, Quebec
Canada H3C 5H7

Tel.: +1 514-954-8219
Fax: +1 514-954-6077

E-mail: icaohq@icao.int
www.icao.int

6. For your information, the proposed amendment to Annex 10, Volume I, is envisaged for applicability on 10 November 2016. Any comments you may have thereon would be appreciated.

7. The subsequent work of the Air Navigation Commission and the Council would be greatly facilitated by specific statements on the acceptability or otherwise of the proposals. Please note that, for the review of your comments by the Air Navigation Commission and the Council, replies are normally classified as “agreement with or without comments”, “disagreement with or without comments” or “no indication of position”. If in your reply the expressions “no objections” or “no comments” are used, they will be taken to mean “agreement without comment” and “no indication of position”, respectively. In order to facilitate proper classification of your response, a form has been included in Attachment D which may be completed and returned together with your comments, if any, on the proposals in Attachment B.

Accept, Sir/Madam, the assurances of my highest consideration.

Raymond Benjamin
Secretary General

Enclosures:

A — Background
B — Proposed amendment to Annex 10, Volume I
C — Rationale
D — Response form

BACKGROUND

1. The proposed amendments arise from a systematic review of the consistency between Annex 10 provisions for satellite-based augmentation system (SBAS) and the corresponding receiver equipment provisions contained in the industry specifications for SBAS avionics (RTCA DO-229D, *Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment*, February 2013). The purpose of the review was to ensure that any minor discrepancies between Annex 10 and RTCA DO-229D that may have been introduced inadvertently over time in the course of the evolution of the two documents are identified and removed.

2. The review was conducted by the NSP in coordination with the relevant RTCA technical group (RTCA Special Committee 159 Working Group 2) and resulted in a number of changes that were mutually agreed between the two groups.

3. Additionally, a number of editorial and/or consequential changes are being proposed.

4. The amendments affect several sections of the GNSS SARPs including:

a) satellite-based augmentation system (SBAS) specifications (Annex 10, Volume I, Chapter 3, 3.7, Appendix B, 3.5);

b) specifications on resistance to interference for GNSS receivers (Appendix B, 3.7); and

c) related guidance material in Attachment D.

— — — — — — — —

ATTACHMENT B to State letter AN 7/1.3.102-14/36

PROPOSED AMENDMENT TO ANNEX 10, VOLUME I

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

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

1.	~~Text to be deleted is shown with a line through it~~.	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
(RADIO NAVIGATION AIDS)

…

CHAPTER 3. SPECIFICATIONS FOR RADIO NAVIGATION AIDS

…

3.7 Requirements for the Global Navigation Satellite System (GNSS)

3.7.1 Definitions

…

Antenna port. A point where the received signal power is specified. For an active antenna, the antenna port is a fictitious point between the antenna elements and the antenna pre-amplifier. For a passive antenna, the antenna port is the output of the antenna itself.

Axial ratio. The ratio, expressed in decibels, between the maximum output power and the minimum output power of an antenna to an incident linearly polarized wave as the polarization orientation is varied over all directions perpendicular to the direction of propagation.

…

3.7.3.4.4.3 *Signal power level*

3.7.3.4.4.3.1 Each SBAS satellite shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the ~~output~~ antenna port of a 3 dBi linearly polarized antenna is within the range of –161 dBW to –153 dBW for all antenna orientations orthogonal to the direction of propagation.

3.7.3.4.4.3.2 Each SBAS satellite placed in orbit after 31 December 2013 shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at or above the minimum elevation angle for which a trackable GEO signal needs to be provided, the level of the received RF signal at the ~~output~~ antenna port of the antenna specified in Appendix B, Table B-87, is at least –164.0 dBW.

3.7.3.4.4.3.2.1 *Minimum elevation angle.* The minimum elevation angle used to determine GEO coverage shall not be less than 5 degrees for a user near the ground.

3.7.3.4.4.3.2.2 The level of a received SBAS RF signal at the output of a 0 dBic antenna located near the ground shall not exceed –152.5 dBW.

3.7.3.4.4.4 *Polarization.* The broadcast signal shall be right-hand circularly polarized.

3.7.3.4.4.4.1 *Ellipticity*. The ellipticity shall be no worse than 2 dB for the angular range of ±9.1° from boresight.

…

APPENDIX B. TECHNICAL SPECIFICATIONS FOR THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

…

3.5.4.2 *Geostationary orbit (GEO) ranging function parameters.* GEO ranging function parameters shall be as follows:

…

User range accuracy (URA): an indicator of the root-mean-square ranging error, excluding atmospheric effects, as described in Table B-26.

Note.— All parameters are broadcast in Type 9 message.

Table B-26. User range accuracy

URA	Accuracy (rms)
0	2 m
1	2.8 m
2	4 m
3	5.7 m
4	8 m
5	11.3 m
6	16 m
7	32 m
8	64 m
9	128 m
10	256 m
11	512 m
12	1 024 m
13	2 048 m
14	4 096 m
15	“Do Not Use”

Note.— URA values 0 to 14 are not used in the protocols for data application (3.5.5). Airborne receivers will not use the GEO ranging function if URA indicates “Do Not Use”(3.5.8.3).

…

3.5.5.4 *Range rate corrections (RRC)*. The range rate correction for satellite *i* is:

$$\cancel{RRC_i = \frac{FC_{i,current} - FC_{i,previous}}{t_{i,0f} - t_{i,0f\_previous}}}$$

$$RRC_i = \begin{cases} \dfrac{FC_{i,current} - FC_{i,previous}}{t_{i,0f} - t_{i,0f\_previous}}, & if\ a_i \neq 0 \\ 0, & if\ a_i = 0 \end{cases}$$

where

$FC_{i,current}$	=	the most recent fast correction;
$FC_{i,previous}$	=	a previous fast correction;
$t_{i,0f}$	=	the time of applicability of $FC_{i,current}$; ~~and~~
$t_{i,0f\_previous}$	=	the time of applicability of $FC_{i,previous}$~~.~~; and
a_i	=	fast correction degradation factor (see Table B-34).

…

3.5.5.6.3.1 *Broadcast ionospheric corrections.* If SBAS-based ionospheric corrections are applied, σ^2_{UIRE} is:

$$\sigma^2_{UIRE} = F^2_{pp} \times \sigma^2_{UIVE}$$

where

F_{pp} = (as defined in 3.5.5.5.2);

$\sigma^2_{UIVE} = \sum_{n=1}^{4} W_n \cdot \sigma^2_{n,ionogrid}$ or $\sigma^2_{UIVE} = \sum_{n=1}^{3} W_n \cdot \sigma^2_{n,ionogrid}$

using the same ionospheric pierce point weights (W_n) and grid points selected for the ionospheric correction (3.5.5.5). ~~For~~

If degradation parameters are used, for each grid point:

$$\sigma^2_{\cancel{i}n,ionogrid} = \begin{cases} \left(\sigma_{n,GIVE} + \varepsilon_{iono}\right)^2, & \text{if } RSS_{iono} = 0 \text{ (Type 10 message)} \\ \sigma^2_{n,GIVE} + \varepsilon^2_{iono}, & \text{if } RSS_{iono} = 1 \text{ (Type 10 message)} \end{cases}$$

where

$\varepsilon_{iono} = C_{iono\_step} \left[\frac{t - t_{iono}}{I_{iono}}\right] + C_{iono\_ramp}(t - t_{iono})$;

t = the current time;

t_{iono} = the time of transmission of the first bit of the ionospheric correction message at the GEO; and

$[x]$ = the greatest integer less than x.

If degradation parameters are not used, for each grid point:

$$\sigma_{n,ionogrid} = \sigma_{n,GIVE}$$

Note.— For GLONASS satellites, both σ_{GIVE} and ~~σ_{IONO}~~ ε_{iono} parameters are to be multiplied by the square of the ratio of the GLONASS to the GPS frequencies $(f_{GLONASS}/f_{GPS})^2$.

…

3.5.7.1.2 *SBAS radio frequency monitoring.* The SBAS shall monitor the SBAS satellite parameters shown in Table B-55 and take the indicated action.

…

Table B-55. SBAS radio frequency monitoring

Parameter	Reference	Alarm limit	Required action
Signal power level	Chapter 3, 3.7.3.4.4.3	minimum specified power ~~= –161 dBW~~ maximum specified power ~~= –153 dBW~~ (Note 2)	~~Minimum~~: ~~c~~Cease ranging function (Note 1). ~~Maximum:~~ ~~c~~Cease broadcast.
Modulation	Chapter 3, 3.7.3.4.4.5	monitor for waveform distortion	Cease ranging function (Note 1).
SNT-to-GPS time	Chapter 3, 3.7.3.4.5	N/A (Note 3)	Cease ranging function unless σ_{UDRE} ~~URA~~ reflects error.
Carrier frequency stability	3.5.2.1	N/A (Note 3)	Cease ranging function unless $\sigma^{~~2~~}_{UDRE}$ ~~and URA~~ reflects error.
Code/frequency coherence	3.5.2.4	N/A (Note 3)	Cease ranging function unless $\sigma^{~~2~~}_{UDRE}$ ~~and URA~~ reflects error.
Maximum code phase deviation	3.5.2.6	N/A (Notes 2 and 3)	Cease ranging function unless $\sigma^{~~2~~}_{UDRE}$ ~~and URA~~ reflects error.
Convolutional encoding	3.5.2.9	all transmit messages are erroneous	Cease broadcast.

Notes.—
1. *Ceasing the ranging function is accomplished by broadcasting a URA and σ^2_{UDRE} of "Do Not Use" for that SBAS satellite.*
2. *These parameters can be monitored by their impact on the received signal quality (C/N_0 impact), since that is the impact on the user.*
3. *Alarm limits are not specified because the induced error is acceptable, provided it is represented in the σ^2_{UDRE} and URA parameters. If the error cannot be represented, the ranging function must cease.*

…

3.5.7.3.2 *PRN mask and Issue of data — PRN (IODP)*. SBAS shall broadcast a PRN mask and IODP (Type 1 message). The PRN mask values shall indicate whether or not data are being provided for each GNSS satellite. The IODP shall change when there is a change in the PRN mask. The change of IODP in Type 1 messages shall occur before the IODP changes in any other message. The IODP in Type 2 to 5, 7, 24 ~~and~~, 25 and 28 messages shall equal the IODP broadcast in the PRN mask message (Type 1 message) used to designate the satellites for which data are provided in that message.

…

3.5.7.7.2.6 SBAS shall raise an alarm within 8 seconds if any combination of active data and GNSS signals-in-space results in an out-of-tolerance condition for en-route through APV I (3.5.7.4.1).

Note.— The monitoring applies to all failure conditions, including failures in core satellite constellation(s) or SBAS satellites. This monitoring assumes that the aircraft element complies with the requirements of RTCA/DO-229~~C~~D, except as superseded by 3.5.8 and Attachment D, 8.11.

…

3.5.8.1 *SBAS-capable GNSS receiver*. Except as specifically noted, the SBAS-capable GNSS receiver shall process the signals of the SBAS and meet the requirements specified in 3.1.3.1 (GPS receiver) and/or 3.2.3.1 (GLONASS receiver). Pseudo-range measurements for each satellite shall be smoothed using carrier measurements and a smoothing filter which deviates less than ~~0.1~~ 0.25 metre within 200 seconds after initialization, relative to the steady-state response of the filter defined in 3.6.5.1 in the presence of drift between the code phase and integrated carrier phase of up to ~~0.01~~0.018 metre per second.

…

3.5.8.1.1 *Conditions for use of data*. The receiver shall use data from an SBAS message only if the CRC of this message has been verified. Reception of a Type 0 message from an SBAS satellite shall result in deselection of that satellite for at least one minute and all data from that satellite shall be discarded ~~for at least 1 minute~~, except that there is no requirement to discard data from Type 12 and Type 17 messages. For GPS satellites, the receiver shall apply long-term corrections only if the IOD matches both the IODE and 8 least significant bits of the IODC.[…]

…

3.5.8.1.1.5 The receiver shall apply satellite-specific degradation to the $\sigma_{i,UDRE}{}^2$ as defined by a Type 28 clock-ephemeris covariance matrix message. The δ_{UDRE} derived from a Type 28 message with an IODP matching that of the PRN mask shall be applied immediately.

3.5.8.1.1.6 In the event of a loss of four successive SBAS messages during an SBAS-based approach operation, the receiver shall ~~no longer support SBAS-based precision approach or APV operations~~ invalidate all UDREI data from that SBAS satellite.

…

3.5.8.4.1 *Core satellite constellation(s) ranging accuracy.* The root-mean-square (1 sigma) of the total airborne contribution to the error in a corrected pseudo-range for a GPS satellite at the minimum and maximum received signal power level (Chapter 3, 3.7.3.1.5.4) under the worst interference environment as defined in 3.7 shall be less than or equal to ~~0.4~~ 0.36 metres for minimum signal level and 0.15 metres for maximum signal level, excluding multipath effects, tropospheric and ionospheric residual errors. […]

…

3.5.8.4.2 *Precision approach and APV operations*

3.5.8.4.2.1 The receiver shall obtain correction and integrity data for all satellites in the position solution from the same SBAS signal (PRN code).

3.5.8.4.2.~~1~~2 The receiver shall compute and apply long-term corrections, fast corrections, range rate corrections and the broadcast ionospheric corrections. For GLONASS satellites, the ionospheric corrections received from the SBAS shall be multiplied by the square of the ratio of GLONASS to GPS frequencies $(f_{GLONASS}/f_{GPS})^2$.

3.5.8.4.2.~~2~~3 The receiver shall use a weighted-least-squares position solution.

3.5.8.4.2.~~3~~4 The receiver shall apply a tropospheric model such that residual pseudo-range errors have a mean value (μ) less than 0.15 metres and a 1 sigma deviation less than 0.07 metres.

Note.— A model was developed that meets this requirement. Guidance is provided in Attachment D, ~~6.7.3~~ 6.5.4.

3.5.8.4.2.~~4~~5 The receiver shall compute and apply horizontal and vertical protection levels defined in 3.5.5.6. In this computation, $\cancel{\sigma_{tropo}}\sigma_{i,tropo}$ shall be:

$$\cancel{\frac{1}{\sqrt{0{,}002 + \mathrm{sen}^2(\theta_i)}} \times 0{,}12\ \mathrm{m}}$$

$$\frac{1.001}{\sqrt{0.002001 + \sin^2(\theta_i)}} \times 0.12\ \mathrm{m}$$

where θ_i is the elevation angle of the i^{th} satellite.

In addition, $\cancel{\sigma_{air}}\sigma_{i,air}$ shall satisfy the condition that a normal distribution with zero mean and a standard deviation equal to $\cancel{\sigma_{air}}\sigma_{i,air}$ bounds the error distribution for residual aircraft pseudo-range errors as follows:

$$\int_y^{\infty} f_{\cancel{n}i}(x)dx \le Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \ge 0 \text{ and}$$

$$\int_{-\infty}^{-y} f_{\cancel{n}i}(x)dx \le Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \ge 0$$

where

$f_{\cancel{n}i}(x)$ = probability density function of the residual aircraft pseudo-range error and

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-\frac{t^2}{2}} dt$$

Note.— The standard allowance for airborne multipath defined in 3.6.5.5.1 may be used to bound the multipath errors.

3.5.8.4.2.~~5~~6 For precision approach and APV operations, the service provider ID broadcast Type 17 message shall be identical to the service provider ID in the FAS data block, except if ID equals 15 in the FAS data block.

Note.— For SBAS, FAS data blocks are stored in airborne databases. The format of the data for validation of a cyclic redundancy check is shown in Attachment D, 6.6. It differs from the GBAS FAS data block in 3.6.4.5 in that it contains the SBAS HAL and VAL for the particular approach procedure. For approaches conducted using SBAS pseudo-range corrections, the service provider ID in the FAS data block is the same as the service provider ID broadcast as part of the health and status information in Type 17 message. If the service provider ID in the FAS data block equals 15, then any service provider can be used. If the service provider ID in the FAS data block equals 14, then SBAS precise differential corrections cannot be used for the approach.

3.5.8.4.3 *Departure, en-route, terminal, and non-precision approach operations*

3.5.8.4.3.1 The receiver shall compute and apply long-term corrections, fast corrections and range rate corrections.

3.5.8.4.3.2 The receiver shall compute and apply ionospheric corrections.

Note.— Two methods of computing ionospheric corrections are provided in 3.1.2.4 and 3.5.5.5.2.

3.5.8.4.3.3 The receiver shall apply a tropospheric model such that residual pseudo-range errors have a mean value (μ) less than 0.15 metres and a standard deviation less than 0.07 metres.

Note.— A model was developed that meets this requirement. Guidance is provided in Attachment D, ~~6.7.3~~6.5.4.

3.5.8.4.3.4 The receiver shall compute and apply horizontal and vertical protection levels as defined in 3.5.5.6. In this computation, ~~s_{tropo}~~σ_{tropo} shall be~~:~~ obtained either from the formula in 3.5.8.4.2.5, which can be used for elevation angles not less than 4 degrees, or from the alternate formula below, which can be used for elevation angles not less than 2 degrees.

$$\cancel{\frac{1}{\sqrt{0{,}002+\mathrm{sen}^2(\theta_i)}}\times 0.12\ \mathrm{m}}$$

$$\frac{1.001}{\sqrt{0.002001+\sin^2(\theta_i)}}\times\left(1+0.015\times\left(\max(0,4-\theta_i)\right)^2\right)\times 0.12\ \mathrm{m}$$

where θ_i is the elevation angle of the i^{th} satellite.

In addition, ~~σ_{air}~~$\sigma_{i,air}$ shall satisfy the condition that a normal distribution with zero mean and standard deviation equal to ~~σ_{air}~~$\sigma_{i,air}$ bounds the error distribution for residual aircraft pseudo-range errors as follows:

$$\int_{y}^{\infty} f_{\cancel{n}i}(x)dx \le Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \ge 0 \text{ and}$$

$$\int_{-\infty}^{-y} f_{\cancel{n}i}(x)dx \le Q\left(\frac{y}{\sigma}\right) \text{ for all } \frac{y}{\sigma} \ge 0$$

where

$f_{\cancel{n}i}(x)$ = probability density function of the residual aircraft pseudo-range error and

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{-\frac{t^2}{2}} dt$$

Note.— The standard allowance for airborne multipath defined in 3.6.5.5.1 may be used to bound the multipath errors.

…

3.7 Resistance to interference

3.7.1 PERFORMANCE OBJECTIVES

Note 1.— For unaugmented GPS and GLONASS receivers the resistance to interference is measured with respect to the following performance parameters:

	GPS	*GLONASS*
Tracking error (1 sigma)	*~~0.4~~0.36 m*	*0.8 m*

…

Note 6.— The performance requirements are to be met in the interference environments defined below ~~for various phases of flight~~. This defined interference environment is relaxed during initial acquisition of GNSS signals when the receiver cannot take advantage of a steady-state navigation solution to aid signal acquisition.

3.7.2 CONTINUOUS WAVE (CW) INTERFERENCE

3.7.2.1 *GPS AND SBAS RECEIVERS*

3.7.2.1.1 After steady-state navigation has been established, GPS and SBAS receivers ~~used for the precision approach phase of flight or used on aircraft with on-board satellite communications~~ shall meet the performance objectives with CW interfering signals present with a power level at the antenna port equal to the interference thresholds specified in Table B-83 and shown in Figure B-15 and with a desired signal level of ~~164.5~~ 164 dBW at the antenna port.

3.7.2.1.2 ~~GPS and SBAS receivers used for non-precision approach shall meet the performance objectives with interference thresholds 3 dB less than specified in Table B-83. For terminal area and en-route steady-state navigation operations and for~~During initial acquisition of the GPS and SBAS signals prior to steady-state navigation, ~~the~~ GPS and SBAS receivers shall meet the performance objectives with interference thresholds ~~shall be~~ 6 dB less than those specified in Table B-83.

Table B-83. CW interference thresholds for GPS and SBAS receivers in steady-state navigation

Frequency range f_i of the interference signal	Interference thresholds for receivers ~~used for precision approach phase of flight~~ in steady-state navigation
$f_i \leq 1\ 315$ MHz	–4.5 dBW
$1\ 315$ MHz $< f_i \leq$ ~~1 525~~ $1\ 500$ MHz	Linearly decreasing from –4.5 dBW to ~~–42~~ –38 dBW
$1\ 500$ MHz $< f_i \leq 1\ 525$ MHz	Linearly decreasing from –38 dBW to –42 dBW
$1\ 525$ MHz $< f_i \leq 1\ 565.42$ MHz	Linearly decreasing from –42 dBW to –150.5 dBW
$1\ 565.42$ MHz $< f_i \leq 1\ 585.42$ MHz	–150.5 dBW
$1\ 585.42$ MHz $< f_i \leq 1\ 610$ MHz	Linearly increasing from –150.5 dBW to –60 dBW
$1\ 610$ MHz $< f_i \leq 1\ 618$ MHz	Linearly increasing from –60 dBW to –42 dBW*
$1\ 618$ MHz $< f_i \leq 2\ 000$ MHz	Linearly increasing from –42 dBW to –8.5 dBW*
$1\ 610$ MHz $< f_i \leq 1\ 626.5$ MHz	Linearly increasing from –60 dBW to –22 dBW**
$1\ 626.5$ MHz $< f_i \leq 2\ 000$ MHz	Linearly increasing from –22 dBW to –8.5 dBW**
$f_i > 2\ 000$ MHz	–8.5 dBW

* Applies to aircraft installations where there are no on-board satellite communications.
** Applies to aircraft installations where there is on-board satellite communications.

3.7.2.2 *GLONASS RECEIVERS*

3.7.2.2.1 After steady-state navigation has been established, GLONASS receivers ~~used for the precision approach phase of flight or used on aircraft with on-board satellite communications~~(except those identified in 3.7.2.2.1.1) shall meet the performance objectives with CW interfering signals present with a power level at the antenna port equal to the interference thresholds specified in Table B-84 and shown in Figure B-16 and with a desired signal level ~~of –165.5~~ –166.5 dBW at the antenna port.

3.7.2.2.1.1 After steady-state navigation has been established, GLONASS receivers used for all phases of flight (excluding those used for the precision approach phase of flight) and put into operation before 1 January 2017 shall meet the performance objectives with CW interfering signals present with a power level at the antenna port 3 dB less than the interference thresholds specified in Table B-84 and shown in Figure B-16 and with a desired signal level of –166.5 dBW at the antenna port.

Table B-84. CW ~~I~~interference thresholds for GLONASS receivers in steady-state navigation

Frequency range f_i of the interference signal	Interference thresholds for receivers ~~used for precision approach phase of flight~~in steady-state navigation
$f_i \leq$ 1 315 MHz	–4.5 dBW
1 315 MHz < $f_i \leq$ 1 562.15625 MHz	Linearly decreasing from –4.5 dBW to –42 dBW
1 562.15625 MHz < $f_i \leq$ 1 583.65625 MHz	Linearly decreasing from –42 dBW to –80 dBW
1 583.65625 MHz < $f_i \leq$ 1 592.9525 MHz	Linearly decreasing from –80 dBW to –149 dBW
1 592.9525 MHz < $f_i \leq$ 1 609.36 MHz	–149 dBW
1 609.36 MHz < $f_i \leq$ 1 613.65625 MHz	Linearly increasing from –149 dBW to –80 dBW
1 613.65625 MHz < $f_i \leq$ 1 635.15625 MHz	Linearly increasing from –80 dBW to –42 dBW*
1 613.65625 MHz < $f_i \leq$ 1 626.15625 MHz	Linearly increasing from –80 dBW to –22 dBW**
1 635.15625 MHz < $f_i \leq$ 2 000 MHz	Linearly increasing from –42 dBW to –8.5 dBW*
1 626.15625 MHz < $f_i \leq$ 2 000 MHz	Linearly increasing from –22 dBW to –8.5 dBW**
f_i > 2 000 MHz	–8.5 dBW

* Applies to aircraft installations where there are no on-board satellite communications.
** Applies to aircraft installations where there is on-board satellite communications.

3.7.2.2.2 ~~GLONASS receivers used for non-precision approach shall meet the performance objectives with interference thresholds 3 dB less than specified in Table B-84. For terminal area and en-route steady-state navigation operations and for~~ During initial acquisition of the GLONASS signals prior to steady-state navigation, ~~the~~ GLONASS receivers shall meet the performance objectives with interference thresholds ~~shall be~~ 6 dB less than those specified in Table B-84.

3.7.3 BAND-LIMITED NOISE-LIKE INTERFERENCE

3.7.3.1 *GPS AND SBAS RECEIVERS*

3.7.3.1.1 After steady-state navigation has been established, GPS and SBAS receivers ~~used for the precision approach phase of flight or used on aircraft with on-board satellite communications~~ shall meet the performance objectives with noise-like interfering signals present in the frequency range of 1 575.42 MHz ±Bw_i/2 and with power levels at the antenna port equal to the interference thresholds specified in Table B-85 and shown in Figure B-17 and with the desired signal level of ~~–164.5~~ –164 dBW at the antenna port.

Note.— Bw_i is the equivalent noise bandwidth of the interference signal.

3.7.3.1.2 ~~GPS and SBAS receivers used for non-precision approach shall meet their performance objectives with interference thresholds for band-limited noise-like signals 3 dB less than specified in Table B-85. For terminal area and en-route steady-state navigation operations and for~~During initial acquisition of the GPS and SBAS signals prior to steady-state navigation, ~~the~~ GPS and SBAS receivers shall meet the performance objectives with interference thresholds ~~for band-limited noise-like signals shall be~~ 6 dB less than those specified in Table B-85.

3.7.3.2 *GLONASS RECEIVERS*

3.7.3.2.1 After steady-state navigation has been established, GLONASS receivers ~~used for the precision approach phase of flight or used on aircraft with on-board satellite communications~~(except those identified in 3.7.3.2.1.1) shall meet the performance objectives while receiving noise-like interfering signals in the frequency band $f_k \pm Bw_i/2$, with power levels at the antenna port equal to the interference thresholds ~~defined~~ specified in Table B-86 and shown in Figure B-18 and with a desired signal level of ~~–165.5~~ –166.5 dBW at the antenna port.

3.7.3.2.1.1 After steady-state navigation has been established, GLONASS receivers used for all phases of flight (excluding those used for the precision approach phase of flight) and put into operation before 1 January 2017 shall meet the performance objectives while receiving noise-like interfering signals in the frequency band $f_k \pm Bw_i/2$, with power levels at the antenna port 3 dB less than the interference thresholds specified in Table B-86 and shown in Figure B-18 and with a desired signal level of –166.5 dBW at the antenna port.

Note.— f_k is the centre frequency of a GLONASS channel with f_k = 1 602 MHz + k × ~~0.6525~~ 0.5625 MHz and k = –7 to +~~13~~ 6 as defined in Table B-16 and Bw_i is the equivalent noise bandwidth of the interference signal.

3.7.3.2.2 ~~GLONASS receivers used for non-precision approach shall meet their performance objectives with interference thresholds for band-limited noise-like signals 3 dB less than specified in Table B-85. For terminal area and en-route steady-state navigation operations, and for~~During initial acquisition of the GLONASS signals prior to steady-state navigation, ~~the~~ GLONASS receivers shall meet the performance objectives with interference thresholds ~~for band-limited noise-like signals shall be~~ 6 dB less than those specified in Table B-86.

~~*Note.— For the approach phase of flight it is assumed that the receiver operates in tracking mode and acquires no new satellites.*~~

…

3.8.3 *Polarization*. The GNSS antenna polarization shall be right-hand circular (clockwise with respect to the direction of propagation).

3.8.3.1 The antenna axial ratio shall not exceed 3.0 dB as measured at boresight.

…

Table B-85. Interference threshold for band-limited noise-like interference to GPS and SBAS receivers ~~used for precision approach~~in steady-state navigation

Interference bandwidth	Interference threshold for receivers in steady-state navigation
0 Hz < Bw_i ≤ 700 Hz	–150.5 dBW
700 Hz < Bw_i ≤ 10 kHz	Linearly increasing from –150.5 to –143.5 dBW ~~–150.5 + 6 log~~$\cancel{_{10}}$~~(BW/700) dBW~~
10 kHz < Bw_i ≤ 100 kHz	Linearly increasing from –143.5 to –140.5 dBW ~~–143.5 + 3 log~~$\cancel{_{10}}$~~(BW/10000) dBW~~
100 kHz < Bw_i ≤ 1 MHz	–140.5 dBW
1 MHz < Bw_i ≤ 20 MHz	Linearly increasing from –140.5 to –127.5 dBW*
20 MHz < Bw_i ≤ 30 MHz	Linearly increasing from –127.5 to –121.1 dBW*
30 MHz < Bw_i ≤ 40 MHz	Linearly increasing from –121.1 to –119.5 dBW*
40 MHz < Bw_i	–119.5 dBW*

* The interference threshold is not to exceed –140.5 dBW/MHz in the frequency range 1 575.42 ±10 MHz.

Table B-86. Interference threshold for band-limited noise-like interference to GLONASS receivers in steady-state navigation

Interference bandwidth	Interference threshold
0 Hz < Bw_i ≤ 1 kHz	–149 dBW
1 kHz < Bw_i ≤ 10 kHz	Linearly increasing from –149 to –143 dBW
10 kHz < Bw_i ≤ 0.5 MHz	–143 dBW
0.5 MHz < Bw_i ≤ 10 MHz	Linearly increasing from –143 to –130 dBW
10 MHz < Bw_i	–130 dBW

Table B-87. Interference thresholds for pulsed interference

	GPS and SBAS	GLONASS
Frequency range	1 575.42 MHz ± 10 MHz	1 592.9525 MHz to 1 609.36 MHz
Interference threshold (Pulse peak power)	–20 dBW	–20 dBW
Pulse width	≤125 µs	≤250 µs
Pulse duty cycle	≤1%	≤1%
Interference signal bandwidth	≥1 MHz	≥500 kHz

Note.— The interference signal is additive white Gaussian noise centred around the carrier frequency with bandwidth and pulse characteristics specified in the table.

…

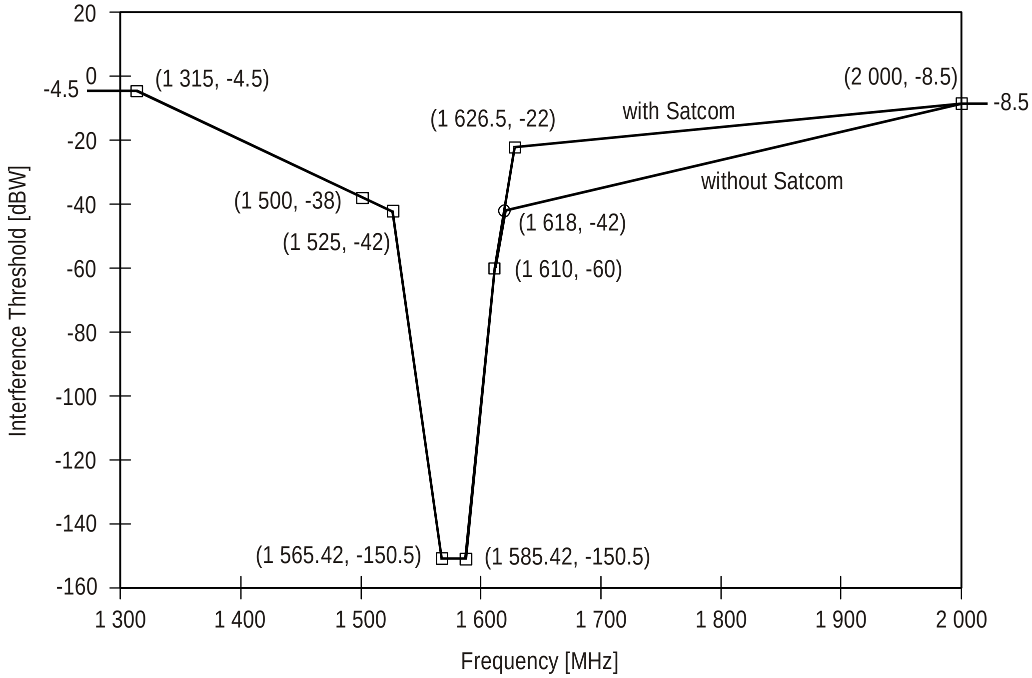

Figure B-15. CW interference thresholds for GPS and SBAS receivers ~~used for precision approach~~ in steady-state navigation

…

Replace Figure B-17 with the figure below.

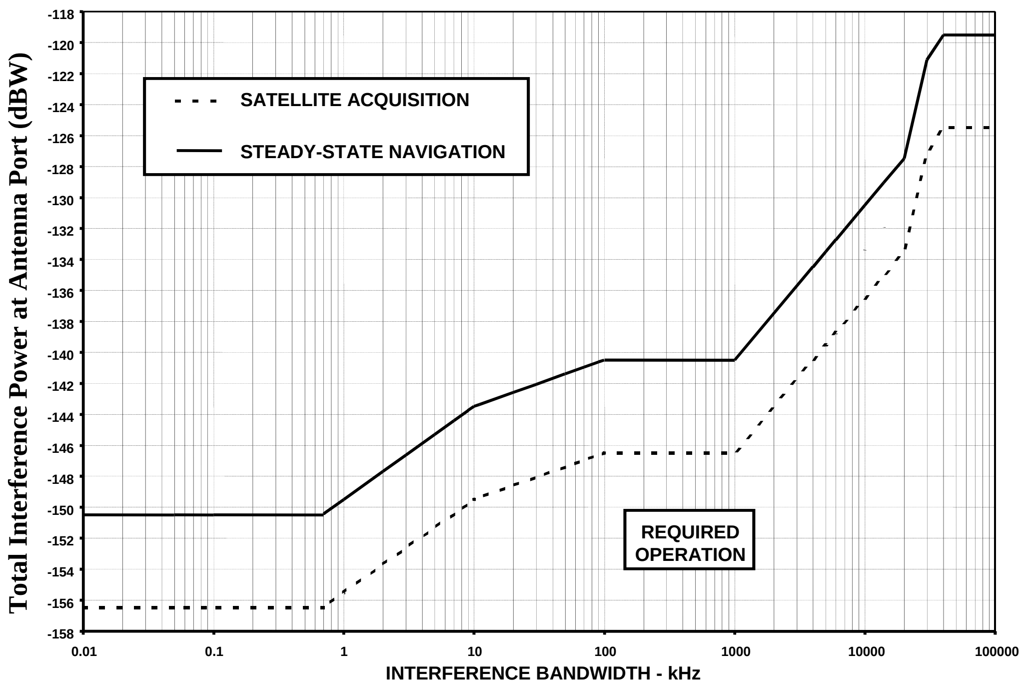

Figure B-17. Interference thresholds versus bandwidth for GPS and SBAS receivers

Replace Figure B-18 with the figure below.

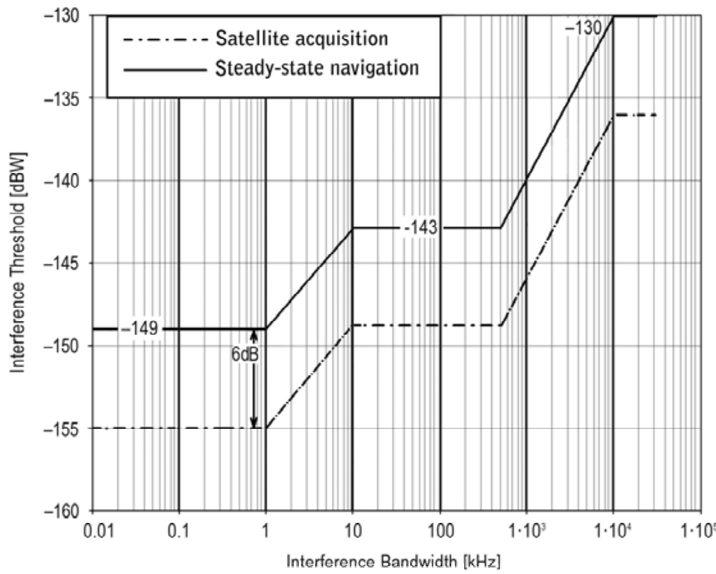

Figure B-18. Interference thresholds versus bandwidth for GLONASS receivers

…

ATTACHMENT D. INFORMATION AND MATERIAL FOR GUIDANCE IN THE APPLICATION OF THE GNSS STANDARDS AND RECOMMENDED PRACTICES

…

3.2.9 SBAS and GBAS receivers will be more accurate, and their accuracy will be characterized in real time by the receiver using standard error models, as described in Chapter 3, 3.5, for SBAS and Chapter 3, 3.6, for GBAS.

Note 1.— The term "SBAS receiver" designates the GNSS avionics that at least meet the requirements for an SBAS receiver as outlined in Annex 10, Volume I and the specifications of RTCA/DO-229~~C~~D, as amended by United States FAA TSO-C145A/TSO-C146A (or equivalent).

…

4.4 GNSS antenna and receiver

4.4.1 The antenna specifications in Appendix B, 3.8, do not control the antenna axial ratio except at boresight. Linear polarization should be assumed for the airborne antenna for GEO signals received at low-elevation angles. For instance, if the minimum elevation angle for which a trackable GEO signal needs to be provided is 5 degrees, the antenna should be presumed to be linearly polarized with −2.5 dBil (−5.5 dBic) gain when receiving this signal. This should be taken into account in the GEO link budget in order to ensure that the minimum received RF signal at the antenna port meets the requirements of Chapter 3, 3.7.3.4.4.3.2.

4.4.~~1~~2 The failures caused by the receiver can have two consequences on navigation system performance which are the interruption of the information provided to the user or the output of misleading information. Neither of these events are accounted for in the signal-in-space requirement.

4.4.~~2~~3 The nominal error of the GNSS aircraft element is determined by receiver noise, interference, and multipath and tropospheric model residual errors. Specific receiver noise requirements for both the SBAS airborne receiver and the GBAS airborne receiver include the effect of any interference below the protection mask specified in Appendix B, 3.7. The required performance has been demonstrated by receivers that apply narrow correlator spacing or code smoothing techniques.

…

6.4.1 *Minimum GEO signal power level.* The minimum aircraft equipment (e.g. RTCA/DO-229D) is required to operate with a minimum signal strength of –164 dBW at the ~~input of the receiver~~antenna port in the presence of non-RNSS interference (Appendix B, 3.7) and an aggregate RNSS noise density of –173 dBm/Hz. In the presence of interference, receivers may not have reliable tracking performance for ~~an input~~a signal strength at the antenna port below –164 dBW (e.g. with GEO satellites placed in orbit prior to 2014). A GEO that delivers a signal power below –164 dBW at the ~~output of the standard~~ receiving antenna port at 5-degree elevation on the ground can be used to ensure signal tracking in a service area contained in a coverage area defined by a minimum elevation angle that is greater than 5 degrees (e.g. 10 degrees). […]
…

6.4.3 *SBAS convolutional encoding.* Information on the convolutional coding and decoding of SBAS messages can be found in RTCA/DO-229~~C~~D, Appendix A.
…

6.5.4 *Tropospheric function.* Because tropospheric refraction is a local phenomenon, users will compute their own tropospheric delay corrections. A tropospheric delay estimate for precision approach is described in RTCA/DO-229~~C~~D, although other models can be used.

8.11.4 For aircraft receivers using early-late correlators and tracking GPS satellites, the precorrelation bandwidth of the installation, the correlator spacing and the differential group delay are within the ranges defined in Table D-11, except as noted below.

8.11.4.1 For GBAS airborne equipment using early-late correlators and tracking GPS satellites, the precorrelation bandwidth of the installation, the correlator spacing and the differential group delay (including the contribution of the antenna) are within the ranges defined in Table D-11, except that the region 1 minimum bandwidth will increase to 4 MHz and the average correlator spacing is reduced to an average of 0.21 chips or instantaneous of 0.235 chips.

8.11.4.2 For SBAS airborne equipment using early-late correlators and tracking GPS satellites, the precorrelation bandwidth of the installation, the correlator spacing and the differential group delay (including the contribution of the antenna) are within the ranges of the first three regions defined in Table D-11.

…

Table D-11. GPS tracking constraints for early-late correlators

Region	3 dB precorrelation bandwidth, BW	Average correlator spacing (chips)	Instantaneous correlator spacing (chips)	Differential group delay
1	2 < BW ≤ 7 MHz	0.045 – 1.1	0.04 – 1.2	≤ 600 ns
2	7 < BW ≤ 16 MHz	0.045 – 0.21	0.04 – 0.235	≤ 150 ns
3	16 < BW ≤ 20 MHz	0.045 – 0.12	0.04 – 0.15	≤ 150 ns
4	20 < BW ≤ 24 MHz	0.08 – 0.12	0.07 – 0.13	≤ 150 ns

…

~~10.2 Specification of the interference threshold at the antenna port~~

~~The indications of the interference threshold levels are referenced to the antenna port. In this context, the term “antenna port” means the interface between the antenna and the GNSS receiver where the satellite signal power corresponds to the nominal minimum received signal power of -164.5 dBW for GPS and -165.5 dBW for GLONASS. Due to the reduced distance from potential interference sources, GNSS receivers that are used for the approach phase of flight must have a higher interference threshold than receivers that are only used for en-route navigation.~~

Renumber sections 10.3 – 10.6 to reflect the deletion of section 10.2

— — — — — — — —

Proposed change	Rationale
Chapter 3	
3.7.1	The term "antenna port" is used several times in the GNSS SARPs. It is currently incorrectly defined in Attachment D, 10.2, and the scope of applicability of that definition is unclear. Rather than correct the text in Attachment D, it has been thought preferable to delete it (see below) and introduce a new definition in Section 3.7.1, which will be applicable to all GNSS SARPs. The term "axial ratio" is currently not defined or used in the GNSS SARPs. A definition is required in light of the introduction of the new Standard in Appendix B, 3.8.3.1 (see below) which makes use of the term.
3.7.3.4.4.3.1 and 3.7.3.4.4.3.2	These changes are consequential to the introduction of the definition of "antenna port" in 3.7.1.
3.7.3.4.4.4.1	This new Standard complements the polarization Standard in 3.7.3.4.4.4, by imposing a limit on the ellipticity of the signal (ratio between major and minor axis of the polarization ellipse). Without the new Standard, the existing Standard in 3.7.3.4.4.4 would imply ideal right-hand circularly polarization (ellipticity = 0 dB). This is not achievable in practical implementation. The proposed changes align the SARPs with the industry standard for SBAS avionics, RTCA DO-229D, *Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment*, February 2013.
Appendix B	
3.5.4.2	The proposed changes align the SARPs with RTCA DO-229D, which reflects the actual behaviour of SBAS avionics, whereby values of URA other than 15 are not used by the avionics.
3.5.5.4	The proposed changes align the SARPs with RTCA DO-229D by correcting an omission in the existing Standard, which ignores the case in which the fast correction degradation factor is zero (and consequently the range rate correction factor must be zero too).
3.5.5.6.3.1	The degradation parameters used to calculate $\sigma_{n,ionogrid}$ are provided in message Types 7 and 10, whose transmission is not mandatory. This proposal introduces a formula to calculate $\sigma_{n,ionogrid}$ if the degradation parameters are not available.
3.5.7.1.2, Table B-55	The deletion of references to URA is consequential to the changes to 3.5.4.2. The deletion of the minimum and maximum power values (respectively – 161 dBw and – 153 dBW) reflects the fact that, following Amendment 87, two different power ranges apply depending on whether a satellite was placed in orbit after 31 December 2013 or not.

Proposed change	Rationale
3.5.7.3.2	This change corrects the inadvertent omission of Type 28 in the list of messages carrying an IODP field.
3.5.7.7.2.6	Updated reference (latest edition of referenced RTCA document)
3.5.8.1	The current Standard is based on the assumption that the code-carrier divergence would remain below 0.010 metre per second. However, data collected from SBAS reference stations indicated that the rate could be larger than 0.010. Accordingly, the value 0.018 metre per second was chosen as a more realistic maximum value in RTCA DO-229D, and the allowed maximum deviation was increased accordingly to 0.25 metre. The proposed change is intended to align the SARPs with RTCA DO-229D.
3.5.8.1.1	Transmission of a Type 0 message means that the SBAS satellite that transmitted the message should not be used for safety applications (for example, because the satellite is undergoing testing). Consequently, in general the data obtained from that satellite should also be discarded. Type 12 and 17 messages, however, do not have to be discarded as they do not convey navigation information and, as such, have no safety implications, whereas their use can enable potential performance enhancements.
3.5.8.1.1.5	The new text clarifies that the information derived from Type 28 messages should be used only if it is associated with the unique pseudo-random noise (PRN) mask identifying the signal to be corrected. This is consistent with RTCA DO-229D.
3.5.8.1.1.6	The current Standard in 3.5.8.1.1.6 does not specify a mechanism to trigger the indication of loss of navigation capability when four consecutive SBAS messages are lost (indicating a probable communications link problem). Instead, it contains a broad general statement (“no longer support SBAS-based precision approach or APV operations”), which lends itself to different interpretations, both with regard to the duration of the loss of navigation capability and to the mechanism through which an indication of loss of navigation should be triggered. The current proposal aims to align the SARPs with RTCA DO-229D. The receiver behaviour specified in DO-229D is to discard all user differential range error indicator (UDREI) so as to trigger an immediate indication of loss of navigation capability. This approach enables a quick return to normal operation when SBAS message transmission resumes, as new UDREI data can be reacquired in a short time. This constitutes an advantage over the current Standard, which, as mentioned, does not specify by which means the loss of navigation should be indicated.
3.5.8.4.1	This proposal introduces more stringent limits on the total airborne contribution to the error (including a new limit applying to the maximum signal level case). The more stringent limits reflect actual achievable performance by current avionics and are consistent with RTCA DO-229D.

Proposed change	Rationale
3.5.8.4.2 and 3.5.8.4.3 (including sub-paragraphs)	The new Standard 3.5.8.4.2.1 is introduced because different SBAS signals (i.e. signals with different PRN codes) may have small discrepancies, which in turn could result in small position errors. These small errors are not considered a practical threat in the case of en route and non-precision approach, but could have a minor impact in the case of PA/APV. The modifications to existing Standards 3.5.8.4.2.4 (now 3.5.8.4.2.5) and 3.5.8.4.3.4 are intended to ensure full consistency with RTCA DO-229D by using more accurate formula(s) to compute the $\sigma_{i,tropo}$ values. Additionally, this proposal corrects some typographical errors in the formulae.
3.7.1, Note 1	Consequential to the changes to 3.5.8.4.1.
3.7.1, Note 6, 3.7.2.1 (including sub-paragraphs), Table B-83, Figure B-15	The current formulation of the GNSS Standards on resistance to interference (Appendix B, 3.7) was based on the assumption that interference decreased at higher altitude as the distance from interference sources increased. Thus, different requirements were defined depending on the different phases of flight for which the GNSS receiver was intended to be used. However, further analysis of the interference environment showed that the assumption was invalid. As the altitude increases, individual external interference sources are indeed farther away (which does decrease their individual contribution to the interference at the aircraft), but more interference sources become visible to the aircraft, so that the aggregate interference level does not decrease. These considerations are reflected in the latest version of RTCA DO-229D in which the requirements on resistance to interference were reformulated to be independent from the phase of flight and to depend only on the receiver acquisition state, namely on whether the GNSS signal has been acquired (steady-state navigation) or is in the process of being acquired (initial acquisition). The present proposal introduces a reformulation of the GPS and SBAS receiver requirements for resistance to continuous wave (CW) interference along similar lines to RTCA DO-229D. Additionally, the desired signal level value in 3.7.2.1.1 is modified as a consequence of the change to Chapter 3, 3.7.3.4.4.3.2 introduced by Amendment 87, and a correction to the interference thresholds defined in Table B-83 is introduced.
3.7.2.2 (including sub-paragraphs), Table B-84	This proposal is based on the same considerations as the changes to 3.7.2.1, applied here to GLONASS receivers. It differs from that case in that it introduces transitional provisions for certain types of GLONASS receivers put into operations before 1 January 2017 (3.7.2.2.1.1). Additionally, the desired signal level value in 3.7.2.2.1 is modified as a consequence of the 1-dB reduction in minimum antenna gain introduced by Amendment 87 (Table B-88).
3.7.3.1 (including sub-paragraphs), Table B-85, Figure B-17	This proposal is equivalent to the changes to 3.7.2.1, but for band-limited noise-like interference (as opposed to continuous wave interference).
3.7.3.2 (including sub-paragraphs), Table B-86, Figure B-18	This proposal is equivalent to the changes to 3.7.2.2, but for band-limited noise-like interference (as opposed to continuous wave interference).

Proposed change	Rationale
3.8.3.1	In the absence of a specification of the maximum acceptable value for the antenna axial ratio, the current Standard 3.8.3 implies ideal right-hand circularly polarization (axial ratio = 0). This is not achievable in practical implementation. Current industry standards for GNSS antennas (RTCA DO-301, *Minimum Operational Performance Standards for Global Navigation Satellite System (GNSS) Airborne Active Antenna Equipment for the L1 Frequency Band*) specify a 3-dB limit on the acceptable antenna axial ratio. The proposed change introduces the same limit in the Annex.
Table B-87	The current Table B-87 does not fully specify the characteristics of the pulsed interference signal referred to by the interference resistance Standard in 3.7.3.3 because the bandwidth of the interference signal is not defined. The interference signal bandwidth is, however, specified in RTCA DO-229D. This proposal aligns the Annex 10 requirement with RTCA DO-229D.
Attachment D	
3.2.9 Note 1, 6.4.3 and 6.5.4	Updated reference (latest edition of referenced RTCA document)
4.4 (including sub-paragraphs)	The new text contains clarifications intended to alert SBAS service providers that the SBAS satellite power budget should account for the polarization mismatch loss between the satellite signal and the user antenna at low elevations, in order to ensure that the minimum received signal level is sufficient.
6.4.1	These changes are consequential to the introduction of the definition of "antenna port" in 3.7.1.
8.11.4 (including sub-paragraphs), Table D-11	The proposed changes are intended to align the SARPs to RTCA DO-229D. The changes to paragraph 8.11.4.1 simply highlight the fact that the antenna contribution must be included when computing the differential group delay, as explicitly stated in DO-229D. The new paragraph 8.11.4.2 has been added to clarify that the fourth row of Table D-11 is not applicable to SBAS receivers.
10.2 – 10.6	Consequential to the changes to Chapter 3, 3.7.1 and Appendix B, 3.7.2 and 3.7.3.

— — — — — — — —

RESPONSE FORM TO BE COMPLETED AND RETURNED TO ICAO TOGETHER WITH ANY COMMENTS YOU MAY HAVE ON THE PROPOSED AMENDMENTS

To: The Secretary General
International Civil Aviation Organization
999 University Street
Montreal, Quebec
Canada, H3C 5H7

(**State**) ________________________________

Please make a checkmark (✓) against one option for each amendment. If you choose options "agreement with comments" or "disagreement with comments", **please provide your comments on separate sheets.**

	Agreement without comments	*Agreement with comments**	*Disagreement without comments*	*Disagreement with comments*	*No position*
Amendment Annex 10 — *Aeronautical Telecommunications*, Volume I — *Radio Navigation Aids* (Attachment B refers)					

* "Agreement with comments" indicates that your State or organization agrees with the intent and overall thrust of the amendment proposal; the comments themselves may include, as necessary, your reservations concerning certain parts of the proposal and/or offer an alternative proposal in this regard.

Signature ________________________________ Date ________________________________

— END —