RTCA Paper No. 002-25/SC159-1121 Washington, 6 January 2025

EUR 003-25 / WG62-154 Saint-Denis, 6 January 2025

Summary of the One Hundred and Seventeenth Meeting

Special Committee 159 (SC-159)

Navigation Equipment Using the Global Navigation Satellite System (GNSS)

And

Seventy Second Meeting

EUROCAE Working Group 62 (WG-62)

GNSS

The one hundred and seventeenth meeting of SC-159 was held on October 25, 2024, in person and virtually, from 9:00 a.m.to 3:00 p.m., Eastern Daylight Time. The meeting was held jointly with the seventy second meeting of EUROCAE WG-62 (GNSS). The attendees were the following:

NAME	COMPANY
Christopher Hegarty (Co-Chairman)	The MITRE Corporation
George Ligler (Co-Chairman)	Texas A&M University
Wes Googe (Secretary)	American Airlines
Mikael Mabilleau (WG-62 Secretary)	EUROCONTROL
Hamza Abduselam (GAR)	Federal Aviation Administration (FAA)
Karan Hofmann (Program Director)	RTCA
Mark Watson (Technical Programme Manager)	EUROCAE

NAME	COMPANY
Alessandro Adinolfi	ANAC-Brazil
Ken Alexander	Federal Aviation Administration (FAA)
Andy Alfiero	Allied Pilots Association
Capucine Amielh	Airbus
John Ashley	The MITRE Corporation
Laurent Azoulai	Airbus
John Barry	Federal Aviation Administration (FAA)
Elodie Bernadotte	CNES
Nuria Blanco-Delgado	European Satellite Services Provider
Jason Burns	Federal Aviation Administration (FAA)
Natali Caccioppoli	EUROCONTROL
Stefano Caizzoue	DLR
Ettore Canestri	EUSPA

Tim Cashin	The MITRE Corporation
Christina Clausnitzer	Federal Aviation Administration (FAA)
Jed Dennis	FAA/NAVTAC
Mark Dickinson	Federal Aviation Administration (FAA)
Yi Ding	Esterline CMC Electronics
Alessandro Donatelli	EUSPA
Andrew Elliot	US Air Force/ US Space Force
Philippe Estival	DSNA
Davide Ferraro	Leonardo
John Foley	Garmin Ltd.
Joseph Gillespie	Federal Aviation Administration (FAA)
Boyuan Gong	COMAC
Matt Harris	The Boeing Company
Ruth Hirt	Federal Aviation Administration (FAA)
Toru Ishita	Japan Radio Air Navigation Systems Association
Sai Kalyanaraman	Collins Aerospace
Jeff Kerr	Federal Aviation Administration (FAA)
Kuang Keyuan	CETCA
Vignesh Krishnan	Honeywell International
Yang Lelin	CETCA
Tieshuai Li	COMAC
Andreas Lipp	EUROCONTROL
Fan Liu	Federal Aviation Administration (FAA)
Matthew M. Lug	US Air Force
Michael McDowell	Collins Aerospace
Aurélien Merle	DSNA
Tim Murphy	The Boeing Company
Christophe Ouzeau	Collins Aerospace
Ga Oyijia	COMAC
John Owen	Defence Science Technology Laboratory (DSTL)
Kristi Peterson	Federal Aviation Administration (FAA)
Doug Phifer	Federal Aviation Administration (FAA)
Susumu Saito	Electronic Navigation Research Institute (ENRI)
Pradipta Shome	Federal Aviation Administration (FAA)
John Studenny	CMC Electronics
Ki Tamura	ENRI
Francois Tranchet	Airbus
Hans Trautenberg	EASA
Joel Wichgers	Collins Aerospace
Hu Yaying	COMAC
Mike Zaiko	Zeta Associates
Zhang Ziwu	COMAC

AGENDA

1. Introductory Remarks: RTCA, EUROCAE, GAR and Co-Chairs

2. Approval of Summaries of Previous Meetings
   a. One Hundred Sixteenth Meeting for SC-159 and Seventieth Meeting for WG-62 held March 22, 2024 (RTCA Paper No 094-24/SC159-1116 / EUROCAE Reference Number 007-24/WG 62-144)
   b. Seventy First Meeting for WG-62 (jointly with SC-159 WG-2) held June 24-28, 2024 (EUR 225/WG62-148)

3. DO-292A Status
   a. DO-292A (WG-6) FRAC Resolution Update
   b. Consider DO-292A for approval to close FRAC Resolution and forward to PMC for Publication approval

4. DO-373A Status
   a. DO-373A (WG-7) FRAC Resolution Update
   b. Consider DO-373A for approval to close FRAC Resolution and forward to PMC for Publication approval

5. Review Working Group (WG) Progress and Identify Issues for Resolution

   a. BeiDou (WG-62 SG-1) Activity Update
   b. GPS/WAAS (WG-2 and EUROCAE WG-62) to include update on related ICAO/Navigation Systems Panel Activities
   c. GPS/Precision Landing Guidance (WG- 4), to include update on related ICAO/Navigation Systems Panel Activities
   d. GPS/Interference (WG-6), to include update on related ICAO/Navigation Systems Panel Activities
   e. GPS/Antennas (WG-7)

6. Discussion of Terms of Reference Updates

7. Action Item Review

8. Assignment/Review of Future Work

9. Other Business

10. Date and Place of Next Meeting

11. Adjourn

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* Hamza Abduselam, Federal Aviation Administration (FAA), was the Government Authorized Representative for this meeting.

Agenda Item 1. Introductory Remarks: RTCA, GAR and Co-Chairs

- **SC-159 Co-Chairman Dr. George Ligler called the Plenary to order at 9 am and welcomed everyone to the meeting**.This Plenary meeting was convened as the regularly scheduled Fall biannual meeting. He hoped that all was well and was looking forward to hearing all the reports. Dr. Ligler then went back to Mrs. Hofmann and Mr. Watson, Technical Programme Manager of EUROCAE to review the guiding policies for this joint RTCA/EUROCAE Plenary.
- Karan Hofmann, SC-159 Program Director at RTCA, first noted that this would be her last SC-159 meeting as she would be retiring in the following week. She then continued that that meetings are conducted in strict accordance with U.S. anti- trust laws. She discussed RTCA's export compliance policy, proprietary references policy and committee participation membership policy. She then reemphasized the importance of proprietary property as it is coming up increasingly. Mrs. Hofmann noted that this Plenary meeting is open to the public, and that notice of the meeting was published online and that members of the public may present written or oral statements with the permission of the committee chairpersons and program director.
- Mark Watson, Technical Programme Manager of EUROCAE, discussed EUROCAE's Intellectual Property Rights and Membership policies as well as General Data Protection and Privacy regulations. He also reminded all that Russia was still excluded from participating in EUROCAE activities. He commented that if any participants online were from Russia, they would be asked to leave the meeting.
- Then Dr. Ligler then introduced the SC-159 leadership team. Then Dr. Ligler asked those in the room to introduce themselves. He then asked for those on the web to introduce themselves and their company affiliation.

Agenda Item 2. Approval of Summaries of Previous Meetings

a) The summary for the 116th meeting of SC-159 and Seventieth Meeting for WG-62 held on March 22, 2024 (RTCA Paper No. 094-24/SC159-1116 / EUROCAE Reference Number 007-24/WG62-144), was presented to the meeting. Meeting attendees were asked to review the summary and provide any comments to RTCA. **Dr. Ligler asked the group if there were any changes needed for the minutes beyond what had already been submitted. There were no comments from the group, so Dr. Ligler dispositioned that the minutes were approved.**

b) The summary for the 71st meeting of WG-62 (and SC-159 WG-2) held on June 24 – 28, 2024 (EUR 225-24/WG62-148), was previously circulated and posted to AerOpus. **Mikael Mabilleau (WG-62 secretary) commented that this last meeting had multiple topics presented, more than in the past. All documents were posted in July. He then asked if there were any comments on the summary. There were none so Mr. Mabilleau**

considered them approved.

Then Dr. Ligler asked for any other comments. None were heard so asked that all summaries be approved and they were. He then turned to Agenda item 3.

Agenda Item 3. DO-292A Status

Item 3a DO-292A (WG-6) FRAC Resolution Update

Dr. Ligler asked if there were any comments on the document. He remarked that it had been some months since FRAC was completed on 292A and he was looking for any final comments before entering into a motion to submit the document to the PMC. Ms. Hofmann added that the final copy had already been sent back out and she had not received a no vote to date.

Item 3b Consider DO-292A for approval to close FRAC Resolution and forward to the PMC for publication approval

Dr. Ligler asked if there was any comment or dissent on a motion to close FRAC of 292A and forward the document to the PMC. There were no comments, and the motion was considered approved.

Agenda Item 4. DO-373A Status

Dr. Ligler proposed to the plenary that this agenda item be postponed until WG-6 reports. This item was tabled and Dr. Ligler asked that the meeting move to agenda item 5

Agenda Item 5. Review Working Group (WG) Progress and Identify Issues for Resolution

Item 5a Beidou (WG-62 SG-1) Activity Update

Dr. Ligler asked Mr. Boyoun Gang to present his report.

BDS Status

1. **Constellation Status**

   A total of 50 satellites operational in orbit

   - **15 BDS-2 satellites**
   - **35 BDS-3 satellites (30 networking satellites, 5 satellites under in-orbit testing)**

2. Service Performance

- **BDS provides positioning, navigation, and timing services for global users on the ground and 1,000 km above sea level**
- **The horizontal accuracy is better than 2m, the vertical accuracy is better than 4m**
- **The continuity of BDS during 2023 is 0.9998/h**
- **The availability of BDS during 2023 is 0.9968**

BDSBAS Status

1. Introduction

- **BeiDou Satellite based Augmentation System (provides services to users in China and surrounding areas in accordance with the International Civil Aviation Organization (ICAO) standards**
- **The space segment of BDSBAS includes three Geostationary Earth Orbit (GEO) satellites, located at 80 E (PRN 144), 110 5 E (PRN 143) and 140 E (PRN 130) respectively**
- **The BDSBAS ground segment consists of 27 Monitoring Stations (MSs), 2 Data Processing Centers (DPCs) located at Beijing and Xi'an, 1 Operation Control Center (OCC) located at Beijing and 3 Uplink Stations (USs) located at Beijing, Kashgar and Sanya**

2. Update of Space segment

- **The fourth GEO satellite was successfully launched on May 17, 2023, orbiting at 160° E as an on-orbit backup satellite.**

3. Service Evaluation

The performance of BDSBAS from January to June 2024:

- **Position accuracy**
  - **SF service: HPE(95%)=2.3m, VPE(95%)=3.5m**
  - **DFMC service: HPE(95%)=0.9m, VPE(95%)=1.4m**
- **During the evaluation period, no HMI occurred**
- **Availability of both services are better than 99.9%**
- **BDSBAS SF service augments GPS**
- **BDSBAS DFMC service augments both BDS and GPS**

4. Standards Promotion

- **The requirements and elements of BDS and BDSBAS were added in ICAO Annex 10 Volume I: Radio Navigation Aids Eighth Edition, which was published in July 2023**
- **The BDS Standardization Working Group has been working with EUROCAE and RTCA A EUROCAE sub-group,"WG 62 SG-1 Internal Report on BDS and BDSBAS", was approved by the EUROCAE TAC at its 88th meeting. The Internal Report on BDS and BDSBAS is scheduled to be completed in 2024**

- **Participated in the development of SBAS maritime standard "Satellite Based Augmentation System (L1- Receiver Equipment-Performance standards, methods of testing and required test results (IEC 61108-7) which was released in May 2024**

At the conclusion of the report, Dr. Ligler indicated that Mr. Gang had requested a review and comment on a Beidou white paper by this group. He asked the group if they had any comments on conducting this Review and Comment (RAC). Ms. Hofmann indicated that RTCA was talking to Mr. Gang . This review would be like the RAC conducted on the RTCA AerOpus site. Since there was no hurry, she offered that it would take longer to complete. Dr. Ligler offered that we need a plenary agreement that will put this review into motion. If we get the approval, then Ms. Hofmann and Mr. Mallibeau post the document as quickly as possible. Dr. Ligler then identified some steps to get this process moving forward. First, he discussed that the group needed approve this RAC so the RAC/peer review process could begin. He then asked Mr. Mallibeau or Mr. Watson how members of WG1/WG62 could access this document. Mr. Watson replied that there was an agreement with RTCA to use AerOpus. Any WG62 member could ask for access or EUROCAE could send out an Microsoft Excell file for those interested members to fill out. **Dr. Ligler stated that the review and comment period would last for 30 days. Mr. Wichgers then offered this as a motion to the group with the understanding that it would not be a shorter period and could possibly be longer**. **There were no objections.**
Dr. Ligler looked to Ms. Hofmann and Mr. Watson for comments. They both agreed that it could be closed out on November 25th. Mr. Mallibeau asked what would happen next. Dr. Ligler answered that the results would be brought to the March 2025 plenary for discussion. Mr. Azoulai offered that later WG-2 may have some additional work that may require an interim plenary a month earlier from the scheduled March 2025 plenary. Dr. Ligler indicated that if we decide to have an interim plenary then we would consider the results of this WG-1 work as it pertains to WG-2 activity. So, we will review this WG-1 work either in the March plenary or at an earlier one if conducted. Ms. Hofmann added that all comments will have to be resolved by joint WG activity before presenting at a plenary. Mr. Mallibeau agreed to organize this activity with WG-1 taking the lead but making sure that others would be included. Dr. Ligler closed the discussion and asked for Mr. Azoulai to conduct the WG-2 briefing.

Item 5b. GPS/WAAS (WG-2 and EUROCAE WG-62) to include update on related ICAO/Navigation Systems Panel activities

Laurent Azoulai (Co-Chair) began his portion of the briefing by stating that this would be his last briefing to SC-159 as the co-chair of WG-2. He has moved to a different position in the Airbus organization and will still monitor WG-2 activities. He added that there were many presentations during the three days of meetings.

Summary: Papers List & Discussion items (1/3)

- Joint WG-2/WG-4/EUROCAE WG-62 meetings in run mode
  - 2 times in Europe, 2 times in the US,
  - 3-hours teleconferences (the Author's group) from SC-159 & WG-62 on a regular basis
  - Editor's group in place responsible for the master document and integration of evolutions, publish an update on a regular basis to perform advanced review and processing of comments:
    - Fan Liu, FAA, Lead Editor
    - Christophe Ouzeau, Collins Aerospace
    - François Tranchet, Airbus Defense & Space
    - John Foley, Garmin
  - Frequent Spoofing ad-hoc group led by John Studenny to develop Appendix W

Summary: Papers List & Discussion items (Cont)

- **Overview of papers: A summary with some highlights is provided in this briefing and reflects the discussions. For details, please refer to the papers that will be distributed soon after the meeting.**
  - 2.a Galileo Status (Ettore Canestri)
  - 2.b EGNOS status (Ettore Canestri)
  - 2.c Beidou Status (CETC)
  - 2.d ICAO 14th Air Navigation Conference recommendations relative to GNSS (Laurent Azoulai)
  - 4.a AI 66/35 - Develop a conops linked to selection/deselection of SBAS provider and core constellation considering aircraft and ANSP views (Christina Clausnitzer, John Barry, Jed Dennis)
  - 4.b Pilots trial on a simulated DFMC cockpit (Capucine Amielh)
  - 7.a ED-259B/D0-401A maintenance (Fan Liu)

- **7.b Status on ED-259 Appendix C + justification paper (Christophe Ouzeau)**
- **7.c New timing requirements ([DMS:765], [DMS:830], and [DMS:831]) (Christophe Ouzeau)**
- **7.d Updated measurement accuracy test procedure (Christophe Ouzeau)**
- **7.e Clarifying requirements for LNAV/VNAV approach with a specified SPID (AI-62_3) (John Foley)**
- **7.g Spoofing: report ad-hoc activities (John Studenny)**
- **7.h Spoofing: Suggested spoofing/jamming RFI environment characterization activity (Christophe Macabiau)**
- **7.i Spoofing: EUROCONTROL experimentation during Jammertest 2024 (Gary Berz)**
- **7.j Spoofing: Limiting the SBAS rate correction and potential spoofing impact (Todd Walter)**
- **7.k ARAIM: Algorithm appendix, requirements, and test procedure updates (Fan Liu)**
- **7.l ARAIM: GPS ISM processing requirements (Jed Dennis)**
- **7.m ARAIM: GAL ISD requirements (Mikael Mabilleau)**
- **7.q Error models during filter transient phase (Mikael Mabilleau)**
- **7.r Independence of constellation for UTC output (Mikael Mabilleau)**
- **7.t Reaction Time for SBAS Service Provider Designation (François Tranchet)**
- **7.w unsmoothed pseudo range accuracy (Vignesh Krishnan)**
- **7.x Spoofing: Southeast Mediterranean Jamming and Spoofing Observations (Todd Walter)**
- **8.a Review of actions (Mikael Mabilleau)**
- **8.b ED-259B/DO-401A wrap up (Fan Liu)**
- **8.c Work Plan, scope, and schedule of ED-259B/DO-401A (All)**

2.a Galileo status (Ettore Canestri)

Galileo constellation status

- **GSAT 0225 and GSAT 0227** were launched on April 28th at 00:34 UTC. The satellites are positioned in slots C05 and C12 of the constellation (announced through NAGU2024020) using SVID29 (GSAT0225) and SVID06 (GSAT0227)
- Satellites have been available for use since September 5th (announced through NAGU2024033.
- **GSAT0226 and GSAT0232** (SVID 32 and 16 respectively) were launched on September 17th at 22:50 UTC. The satellites are planned to be positioned in the slots A02 and A17 in the constellation (announced through NAGU2024038).
- **The inclusion of GSAT 0225 and 0227 rounds up a total of 32 Galileo satellites in orbit.**
- Process for requesting Galileo PRNs posted at GSC
  - Including application form
  - List of assigned ones available as well (none so far)

Galileo launch 12
Apr. 2024

Galileo launch 13
Sept. 2024

#EUSpace 2

One year of OS provision performance shows very good performance
One year of GAL OS NMA observation (see the presentation for details)

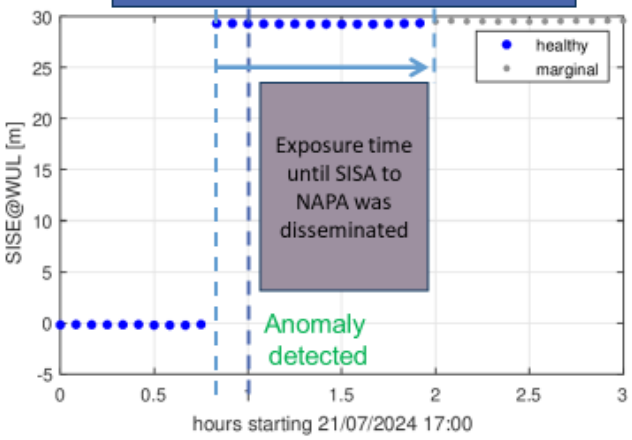
SISE Anomaly on GSAT0102/E12

21.07.2024 17:47 — • Onset of Event

21.07.2024 18:00 — • High SISE detected on ground. As per ULS contact plan, the satellite was disconnected exactly at 17:59 so the SISA to NAPA message was generated on ground right after the last uploaded message.

21.07.2024 19:00 — • Satellite regains Uplink connection
• SISA set to NAPA on SIS

The system reacted as expected during SIS fault demonstrating the good robustness of Galileo against faults

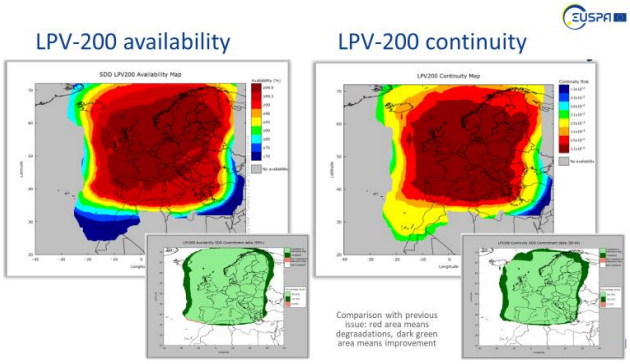


SISE of up to 30m, while SISA was still NOT NAPA

#EUSpace

2.b EGNOS status (Ettore Canestri)

- Large areas have been served with **99.9%** availability (far beyond the 99% mission requirement).
- Solar & ionospheric activity continued to impact EGNOS performance mainly in the **south west (Canary)**
- **Lack of Egypt & Israel RIMS** have impacted EGNOS performance in the **south east (Cyprus, Greek islands)**
- **System anomaly** impacted performance in August



- Published 09/09/2024
- Data campaign from 15/11/2023 – 17/04/2024 with EGNOS release 242B
- Global coverage results:
  - General coverage extension in the borders, especially in the north, thanks to improved robustness of ESR242B against ionospheric events and RIMS Kuusamo (Finland) addition.
  - Slight regressions in southwest (solar activity) and southeast (RIMS HFA temporary unavailability).
- Impacts at user level:
  - APV-I:
    - 11 additional airports achieving the 99% availability in Norway and Iceland. One airport (Madeira, Portugal) with decreased level from 95% to 90%.
    - 53 airports with increased continuity level. 3 airports with regressions.
  - LPV-200:
    - No changes in availability for airports with published LPV200 procedures.
    - Continuity levels improved in 5 airports. No regressions.

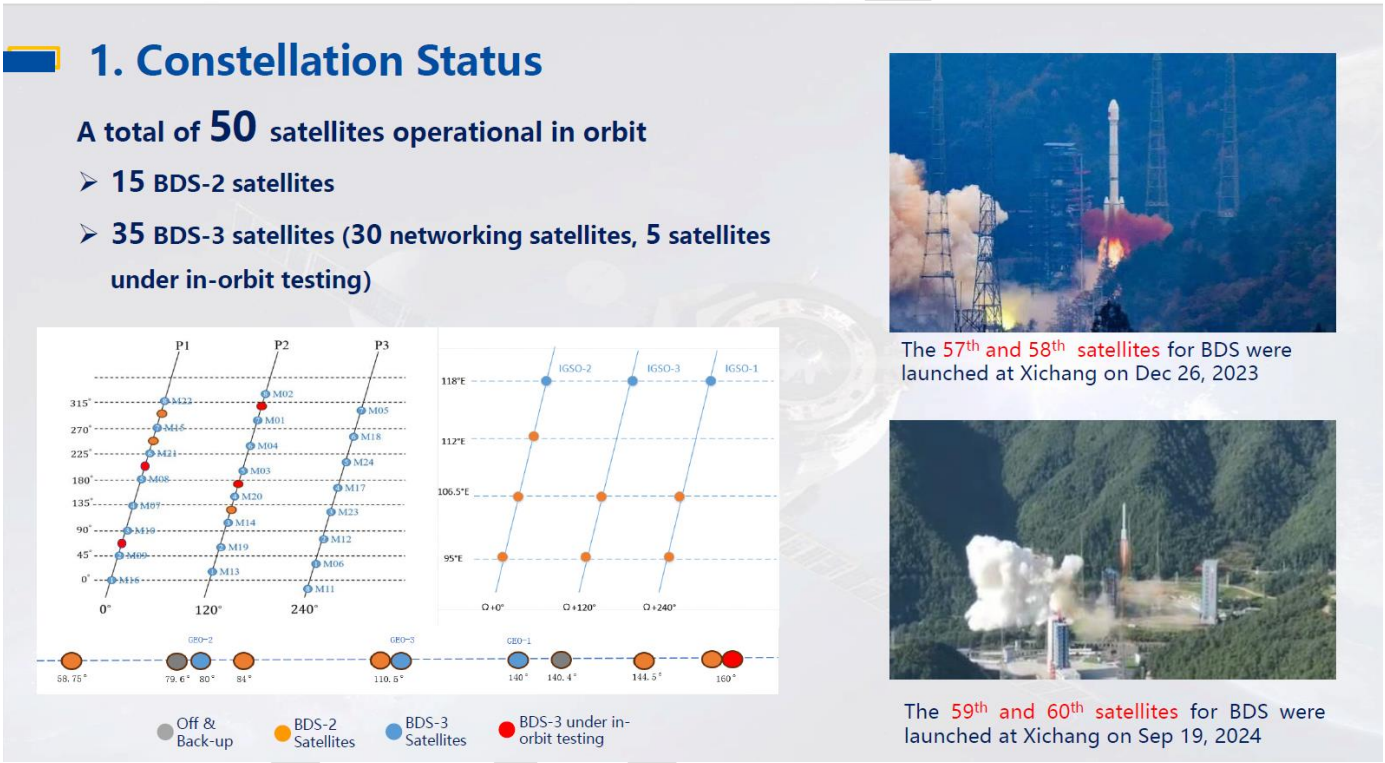
990 EGNOS based operational procedures
72% of Airports Instrumented Runway ends
27% of EU fleet equipped with LPV

- **Projects (excerpt)**
- **DFMC SBAS service demonstrator:** EUSPA is working on the implementation of a DFMC SBAS service demonstrator to support standards validation and receiver prototype activities.
  - EGNSS Service Demonstrator PIN: https://www.euspa.europa.eu/newsroom/news/pin-european-gnss-service-demonstrator
  - Expected first broadcast in 2025
- **R2ISE:** On-board Resilience Techniques against GNSS Frequency Jamming and Spoofing in a GNSS Receiver Prototype or Demonstrator up to TRL 4/5
  - KOM meeting 17/10.
- **Market Consultation on the development of Multi-Element Antenna for GNSS RFI protection Development for Civil applications:** aims at gathering interest in participating in the development of minimum operational standards (MOPS) for multi-element antenna technologies for RFI GNSS protection for civil applications.
  - Deadline for responses November 4th
  - https://www.euspa.europa.eu/opportunities/procurement-grants/procurements/market-consultation-development-multi-element-antenna

WG-2 debated about the opportunity and risks associated with standardizing multiple elements antenna work within ITAR rules: performance achievable and demonstration feasibility with only 3 elements vs risks for US company based and exportations of international carriers and impact on availability. Discussion deferred to WG-7 and awaiting a positive ITAR restrictions removal hopefully by year-end

2.d Beidou status

30 satellites (commitment) 24 MEO And 3 I-GSO and 3 GEOs
Internal report to be completed in 2024

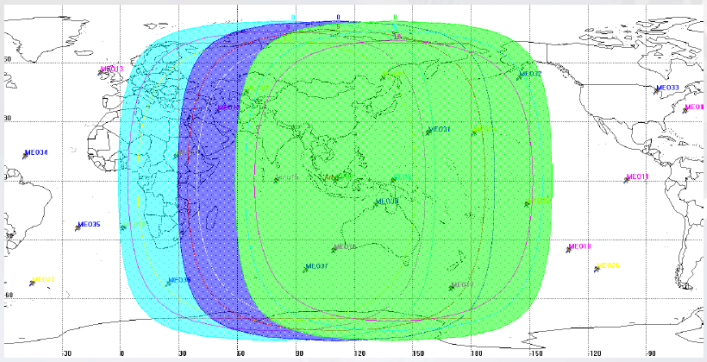


Mr. Azoulai then offered that there is interest in Europe to start Controlled Reception Antenna Pattern (CRPA)design work where it is more relaxed environment to do this work. There is concern from the US side. Mr. Abduselam responded that until ITAR restrictions are lifted, there is not much one could do. We are waiting on the US State Department for further guidance on this issue. At this time, the FAA cannot support this work in the US. Mr. Dennis offered that there had been discussions in the WG that some work could be done within the ITAR restrictions to progress some work. Dr. Ligler commented that this would be consistent with respect to RTCA policy since that is our guidance. Mr. Azoulai then continued his presentation

1. INTRODUCTION

The space segment of BDSBAS includes three Geostationary Earth Orbit (GEO) satellites, located at 80°E (PRN144), 110.5°E (PRN 143), and 140°E (PRN 130), respectively.

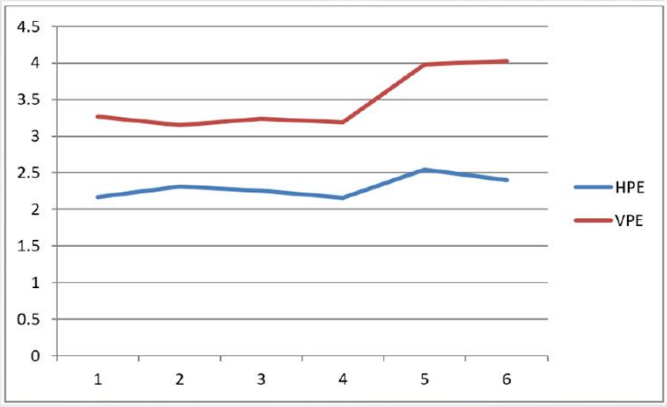
The BDSBAS ground segment consists of 27 Monitoring Stations (MSs), 2 Data Processing Centers (DPCs) located at Beijing and Xi' an, 1 Operation Control Center (OCC) located at Beijing and 3 Uplink Stations (USs) located at Beijing, Kashgar and Sanya.



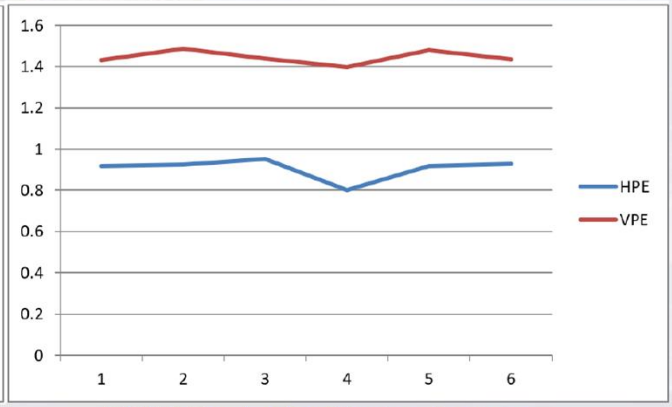
3. SERVICE EVALUATION

The performance of BDSBAS from January to June, 2024:

- Positioning accuracy
  - SF service: HPE(95%)=2.3m, VPE(95%)=3.5m;
  - DFMC service: HPE(95%)=0.9m, VPE(95%)=1.4m;
- During the evaluation period, no HMI occurred;
- Availability of both services are better than 99.9%.



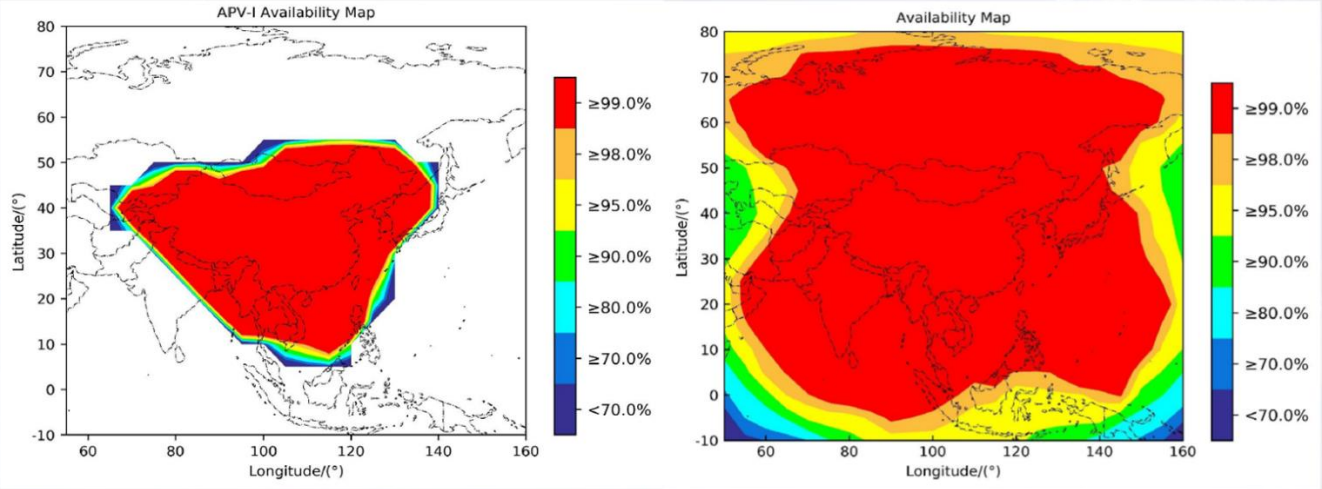
SF Service Positioning Accuracy



DFMC Service Positioning Accuracy

3. SERVICE EVALUATION

- BDSBAS SF service augments GPS
- BDSBAS DFMC service augments both BDS and GPS



The APV-I availability of the BDSBAS SF service

The APV-I availability of the BDSBAS DFMC service

2.c ICAO 14th Air Navigation Conference recommendations relative to GNSS (Laurent Azoulai)

Global navigation satellite system interference & Navigation infrastructure and contingency planning

- GNSS RFI topic was one of the hot topics of the Conference being the subject of several papers (including one from IATA and ICCAIA presented by Airbus) from multiple States as well as Industry organizations.
- Large support from multiple States to all the papers presented and their recommendations.
- Generally, a reminder was given for States to apply ITU rules and to operators to apply regional reporting procedures
- GNSS RFI detection and reporting that is under development at ICAO and RTCA/EUROCAE shall be supported by States
- On GNSS RFI, recommendations included specific harmonized NOTAMs codes, a better coordination between military and civil authorities, the availability of central regional repositories to share data among airspace users and the support from States towards manufacturers to maintain safe and efficient aircraft operations in case of disruption caused by GNSS RFI for instance by enhancing resilience of systems and aircraft.
- On the Navigation infrastructure & contingency planning, several States supported the maintaining and even reinforcement of the conventional navaids including VOR, DME, and ILS, while several States also insisted on maintaining NDB. Accordingly, aircraft minimum equipage lists would need to be updated to ensure the capability to utilize these navaids according to local regulations

ICAO AN-Conf/14 Recommandations on GNSS Interference & Contingency Planning

Recommendation 2.2/2 – Addressing Global Navigation Satellite System (GNSS) Interference and Contingency Planning:

That States:

a) ensure that effective global navigation satellite system radio frequency interference mitigation measures are implemented, based on measures developed by ICAO and industry, including the need to maintain a sufficient network of conventional navigation aids to ensure operational safety as well as sufficient airspace capacity during times of global navigation satellite system interference;

b) through the mechanism of the planning and implementation regional groups, develop regional global navigation satellite system reporting mechanisms to raise operational awareness of affected geographical areas, to the extent feasible, as described in the Global Navigation Satellite System (GNSS) Manual (Doc 9849);

c) work with industry to identify means to make aircraft systems more resilient to radio frequency interference events, and to provide guidance on detecting global navigation satellite system jamming or spoofing and maintaining safe and efficient aircraft operation in case of global navigation satellite system anomalies; and

d) review aircraft minimum equipage lists to ensure compatibility with States' implemented minimum operational networks. *(Secretariat subsequently clarified equipage)*

Recommendation 2.2/2 – Addressing Global Navigation Satellite System (GNSS) Interference and Contingency Planning:

That ICAO:

e) continue to assess the impact of global navigation satellite system interference on aviation safety and continuity of civil aviation operations and define adequate mitigation measures, while reminding States of their obligations;

f) develop a standardized implementation package to assist and guide States in implementing effective global navigation satellite system radio frequency interference mitigation measures, including optimization and rationalization of conventional navigation aids, commensurate with their local conditions, to ensure continuity in the provision of air navigation services;

g) develop guidance on GNSS interference information exchange and civil-military coordination in relation to harmful interference to global navigation satellite system(s) originated or detected by military authorities; and

h) develop recommendations for globally harmonized minimum aircraft equipage lists to ensure that provided navigation infrastructure can be used by airspace users in line with available air traffic services.

4.a AI 66/35 - Develop a conops linked to selection/deselection of SBAS provider and core constellation considering aircraft and ANSP views (Christina Clausnitzer, John Barry, Jed Dennis

Develop a CONOPS linked to selection/deselection of SBAS provider and core constellation considering aircraft and ANSP views (Ref DMS:806/807)

- **Normal Conditions**
- **Default Configuration**
- **Pre-Flight planned Service Changes**
- **Temporary In-Flight Configuration**

WG debated at length on the various parts of the ConOps Challenge to translate the intent and what the aircrews are experiencing into technical requirements. Pre-Flight planned service changes were heavily challenged due to the induced complexity on FMS Return to default configuration before subsequent flight poses some safety requirements challenges. Mechanism to stop polluting GNSS users systems also debated Technical solutions to configure selected/deselected SBAS & core constellations will require updates of interfaces and/or ARINC standardization

4.b Pilots trial on a simulated DFMC cockpit (Capucine Amielh)

Context
Since 2021, Airbus worked on a Human Machine Interface (HMI) integrating DFMC in a cockpit based on the ED-259A concept. From February to April 2024, simulations with pilots were performed on this HMI.

Objective of the evaluation
Get pilot feedback (Human Factor and Operational points of view) on the integration of DFMC in a cockpit and institutional scenarios constraints

Objective of the presentation
Share feedback on simulation of DFMC integration in a cockpit and propose ED-259B requirement modifications

2

AIRBUS

ID	Title	Description
1	In-flight deselection of GPS due to NOTAM	
2	Deselection of SBAS on ground due to NOTAM but inconsistent with LPV approach at destination	Deselection of EGNOS on Ground (due to NOTAM) with UKSBAS available at LFQQ Initialization on ground (London to Lille)
3	GPS and WAAS deselected for LPV approach requiring GPS and WAAS (APD=1)	Crossing US FIR, diversion requiring LPV approach based on those deselected means. Initialization on ground (Havana to Key West)
4	GAL deselected for LPV approach requiring GPS and GAL (APD=2)	Initialization in cruise (from England to Rotterdam)

Conclusion and way forward

- DFMC should not bring extra workload to pilot
  - In nominal situation, selection may be fine but in tense situation it will add an extra unecessary burden
  - Pilots need to focus on the aircraft capacity to meet the current operation performance
- DFMC introduction shall be as mush seamless as possible
  - To limit training costs
  - To not add unnecessary information in cockpit creating burden
- The aircraft navigation performance shall not be degraded due to DFMC considerations
- APD=0 introduces uncertainty in receiver behavior

Modify requirements keeping in mind pilots and airlines constraints:

- Simplicity of use
- Performance
- Cost

WG-2 debated on what "best performance means". No pre-defined criteria could be defined due to the uncertainty between entry into service and longer-term performance of SBAS L5 compared to SBAS L1 best performance criteria are left to manufacturers design choice. Deselection of SBAS per service provider might be needed to comply with institutional scenarios whereas pilots do not want it and interface complexity. APD=0 needs to be clarified in app O, SPID/APD to be displayed on the charts. SBAS L1 as a backup needs to be clarified in APD 5/6.

7.a ED-259B Maintenance (Fan Liu)

Current Changes in ED-259B v0.3+

- **Additional GPS/GAL SF measurement accuracy (Mikael Mabilleau's "Error Models During Filter Transient Phase")**
- **Additional GPS/GAL SF unsmoothed measurement accuracy (Vignesh Krishnan)**
- **GAL ISD requirements (Mikael Mabilleau)**
- **Timing Accuracy (Christophe Ouzeau)**
- **Measurement Accuracy Test (Christophe Ouzeau)**
- **ARAIM appendix, requirements, and test procedures (Fan Liu)**
- **New Appendix R: Example ARAIM Algorithm Description**
- **Other changes**
  - Pass/fail criteria for [DMS:176] and [DMS-O:069.009]
  - Replace "integrity mode" with "integrity monitoring method" (editorial)
  - 5.3.9 24-hour Actual Signal Operation Test
  - 5.3.11 RAIM Provided Integrity Monitoring (editorial)
  - Hyperlinks (cross references, bookmarks, dynamic links) are underlined to indicate a clickable link (editorial)

- **Changes accepted in v0.4**
  - GPS L5 CNAV
  - Satellite Clock and Ephemeris Error
  - UTC Timing requirements
- **Topics need further work**
  - GPS ISD processing
  - ARAIM test procedures

Others

- **Include changes agreed during the meeting**
  - GAL ISD processing
  - Appendix C (merge of the pulsed interference table with L5 BB noise table)
  - Two new requirements on "Reaction Time for SBAS Service Provider Designation"
  - GPS ISD processing
- **The following changes are accepted in WG meeting**
  - Timing accuracy: [DMS:765] and [DMS:831]
  - Measurement accuracy test
  - GPS/GAL SF receiver noise at max power
  - Unsmoothed PR accuracy

7.e Clarifying requirements for LNAV/VNAV approach with a specified SPID (AI-62_3) (John Foley)

AA-62/3

Open Action from July 2022:

AI-62/3	Discuss and agree on SBAS equipment behaviour when flying LNAV/VNAV approach with SBAS and possibility to use a specific SBAS provider for such operation. Check DMS:704 to match DMS:739	M. Mabilleau, J. Barry, J. Foley and Receiver manufacturer	October 2024	Open

There is a concern that some ANSPs may desire and assume a check For the correct SBAS provider when flying an approach to LNAV/VNAV minima. This concern breaks down into two cases:

1. Approaches to LNAV/VNAV minima that are collocated with an an approach to LPV minima.
2. "standalone" approaches to LNAV/VNAV minima that are not defined by an FAS data.

[DMS:704]

- **Changes accepted in v0.4**

[DMS:704] If the aircraft is below 1000ft HAT, or if the LTP/FTP/MAWP is active waypoint, the vertical flag or equivalent indicator shall be displayed withing one second of the onset of any of the following conditions:

a) No position can be computed with SBAS provided integrity monitoring (onset of condition is when the last bit of a message indicating "Do Not Use" from the SBAS L1 or L5 signal in use arrives at the antenna port); or,

b) The horizontal protection level exceeds the alert limit as defined in section 3.2.4.6.1; or,

c) When using SBAS integrity requiring a designated Operational SBAS Service Provider, the calculated position is using an SBAS service provider other than the designated Operational SBAS Service Provider.

Equipment class: Gamma-2; Gamma-3

Note: Condition c) is not intended to preclude the use of any SBAS provider for lateral guidance and integrity for LNAV approaches with baro-VNAV guidance. Appendix O will provide more information on this topic.

At this point in the presentation, Mr. Studenny (co-chair WG-2) assumed presenter duties.

7.g Spoofing: report ad-hoc activities (John Studenny)

Work on Spoofer Equipment

- **4 basic types of spoofers, each in 4 configurations**
  - **Repeaters**
  - **Meaconers (record and play)**
  - **Software Defined Radios**
  - **Professional Grade Simulators**
  - **Configurations:**
    - **One receive antenna (or signal generator), one transmit antenna**
    - **One receive antenna (or signal generator), spatially distributed multiple transmit antennas**
    - **Multiple receive antennas (or signal generator), one transmit antenna**
    - **Multiple receive antennas (or signal generator), spatially distributed multiple transmit antennas (example; emulating GNSS satellites**
  - **The most common spoofer configuration is a one receive, and one transmit antenna and there may be many of them in a local operating zone**
  - **Focus will be on configuration one unless it comes to light that other configurations must also be considered**
- **The spoofer technologies are limited to the above**

S1 to S7 Re-Examined

- **Currently defined S1 to S7 received in light of the above.**
    - **S1 to S7 are operational definitions that have not considered spoofer technologies or capabilities**
    - **It is quite difficult to "fit" spoof technologies into S1 to S7 or to "fit" S1 to S7 into spoofer technologies – that correspondence is many-to-many**
        - **Example: a repeater can cover S1 to S7 operational scenarios**
- **It is proposed that S1 to S7 be re-organized according to what spoofers are capable of doing. Least "sophisticated" are non-targeting, "sophisticated" target victim receivers, "very Sophisticated" target victim receivers identically:**
    - **S1-S4 be grouped into "Non-Targeting Spoofers", all GNSS receivers are affected in some manner. All spoofer technologies apply, and signaling capabilities are limited. This is the majority of today's spoofing scenarios and includes the "circle pattern" Spoofer.**
    - **S5-S6 be grouped into "Targeted Local Area Spoofers" , specific GNSS receivers are affected in a desired manner. All spoofer technologies apply, and signaling capabilities are focused on specific identifiable targets; all other targets are collateral targets.**
    - **S7 be designated as "Targeted Wide Area Spoofers", many GNSS receivers are affected in a desired manner. All spoofer technologies apply, signaling capabilities are focused on all targets within a wide area (spoofed SBAS signals)**
    - **The act of targeting means affecting an individual spoofing victim receiver as desired**

Work to go

- **Develop "stress test" spoofing scenarios**
- **Develop a "Spoofing Resiliency Grade," TBD**
- **The intent of the "Spoofing Resiliency Grade" is that also becomes a part of the TSO Spoofing grade – this is TBD with the Certification Authority's involvement and acceptance.**
- **Spoofing recovery is expected to be mandatory**
- **Spoofing Detection is likely to be graded in terms of capability – this TBD with Everyone's concurrence**
- **Spoofing Mitigation is likely to be graded as well, also TBD**
- **Guiding philosophy: if a GNSS Spoofing Resilient Equipment passes these "stress test" spoofing scenarios, then it is expected to successfully defend against a majority of all spoofers in the current and future spoofing environments. The caveat is: at least to the TBD Spoofing Resilience Grade that it is certified to.**
- **Unknown: the definition of a minimum acceptable Spoofing Resilience Grade**

- **The majority of the current MOS is written without spoofing considerations.**
- **As agreed, Appendix W will be worked until "adequately" complete or at least complete enough to re-examine the MOPS in light of spoofing considerations. Many areas are expected to be affected by spoofing considerations (TTFF post Spoofing attacking, RAIM, alerting, etc…)**
- **MOPS will need new spoofing requirements with the foundation provided by Appendix W**
- **Formal "Spoofing Resilience Grade" as per Appendix recommendations**
- **Schedule: Likely>> 1 year more likely 2.5 or so**
  Schedule depends on contributions and the evolving spoofing threats/solutions (like GNSS authentication?).

  As a metric: assume 1-day/week for any active participant, that yields about 40 man-days/year. The work needs several man-years or several 200 man-days/year; say at least 2000 man-days if not more for all the work envisioned – note, the scenarios have to be developed and tried.

- **App. W approach generated lots of debates with the following thoughts.**
  - **Leadtime estimated around 2.5 years whereas there is an urgent need for fielded receivers, in particular civil airliners. Should we upgrade DO-229 or provide a separate document (white paper with guidance and standardized scenarios with a claim table using an advisory circular or TSO based document ?) for certified receivers leading to potential upgrades: WG agrees to prioritize but needs volunteers to support**
  - **Spoofing technology knowledge is obtained from public sources whereas events are near conflict zones. Can we get some support from Governmental Military to ensure the spoofers tested cover them ? FAA and other MoDs support needed**
  - **Suggestion to have a MASPS and coordinate with others SCs (e.g., SC-227) to have a holistic view from the aircraft perspective. While the receiver is the first line of defense, other SCs and WGs should be linked or**

coordinated with to open other standards such as DO-384 (IRS), DO-283 (FMS) and FAA regs on Clocks

7.h Spoofing: Suggested spoofing/jamming RFI environment characterization activity (Christophe Macabiau)

Conclusion slide for the chairs

ENAC proposes to contribute to the analysis of the GNSS spoofing situations by:

- Contributing to the GNSS antenna/RF/signal processing/observables prediction
- Helping characterize the Pmd determination for GNSS receiver consistency checks, local RAIM, ARAIM
- Helping characterize the integrity risk for the PVT solution and the recovery performance

- This evaluation could further help for:
  - Determination of expected spoofer detector Pmd
  - Determination of continuity performance
  - Definition of test cases which are bouding the other cases of the scenario
- ENAC suggests that the signal processing and the integrity analyses could be started at the minimum from the 6 test cases in ED259A 5.3.7 (Integrity in presence spoofing)
- ENAC started working on that analysis in the ground repeater case (S1) and in the on-board repeater case (one additional potential case of S7)

The WG reviewed two presentations as examples of what can be done from two ENAC PhD students on the impact of low and high-power repeaters on signal processing of a GNSS receiver and impact of meaconers on-board an aircraft. Work on signal processing will be brought to WG-6 and work on Integrity will be brought to WG-2.

After the conclusion of this topic, Mr. Studenny added some comments. He remarked that the single antenna/ receiver is not the end state. This may require other configurations with other systems that will give better performance but we are only in appendix W right now. Dr. Hegarty remarked that in the TAWS (Terrain Alerting and Warning System) there is recognition of Jamming/Spoofing. Mr. Mallibeau added that there was work at ICAO to prevent sole use of one sensor (single point of failure). Dr. Ligler offered that this discussion warrants a multi committee structure to take up this worldwide topic. Dr. Hegarty agreed and indicated that it would be discussed at the next PMC meeting.

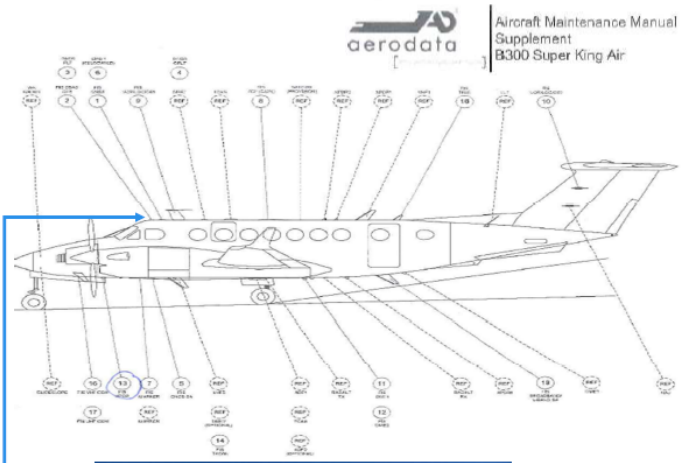
7.i Spoofing: EUROCONTROL experimentation during Jammertest 2024 (Gary Berz)

Flight Test Objectives

- Validate C/N0-based GNSS RFI Indicator defined in ED-259A under controlled interference conditions
  - Detector has been designed primarily for detecting RF jamming
  - Jammertest allows an evaluation of performance also under RF spoofing conditions
  - Could help guide decisions on further developments but priority remains on jamming detection for validation acceptance in ED-259B

Flight Test Equipment

Equipment	Data
NOVATEL PwrPak7	**Rx observables, RFI indicators & PVT outputs**
M3SYSTEMS STELLA NGC	**IQ data**
SEPTENTRIO MOSAIC OSNMA	Rx observables & PVT outputs using antenna inside cockpit
Video recorder	**Cockpit indications and actions**
ADS-B data recorder	**ADS-B out data from on-board ADS-B equipment installation**
Aircraft Flight Inspection system (FIS) antenna	L1 only data connected with PwrPak Rx data & STELLA IQ data recorder



- Equipment data to be processed by EUROCONTROL in **bold**.

Standard Flight Inspection Aircraft with (D)GPS/INS truth reference system and calibrated antennas

Scenarios

Day	RFI Scenarios
Monday	High power noise-like jamming (ramp from 0.2uW to 50W)
Tuesday	Meaconing (1-10W), Sweep CW (50W), high power jamming (100W)
Wednesday	Spoofing (static spoofer, position jump, 0.3 W), Spoofing (slightly moving spoofer, 1W)
Thursday	Time spoofing (time offset, 0.03-1 W), Noise-like, CW very high-power jamming (100W, APCH)

RFI ID	Type
F8.1	High-power jammer with internal gain range of 60 dB in 1 dB steps, antennas are directional with 10 dB gain.
F1.1	Meaconer directional antenna pointing towards the community house in Bleik.
S	Spoofer, stationary antenna on the roof of Bleik community house Expected range/power of spoofing signals: A radius of approximately 1.5 km from the Transmitter
Airport Jammer	Directional very high-power Jammer - RWY 14 towards the sea (northwest)

Flew a total of 11 flights, duration ranging from 1 to 4 hours, nominally at around 5'000ft but also other altitudes depending on test case

Analyses will be provided considering the different interference signals played by JammerTest during the flights data collection

- Analysis of the recorded data and receiver outputs
- Characterisation of the RFI detection flag performance following specification in ED-259B v0.4 under both jamming and spoofing
- Dedicated meetings will be organized with JammerTest 2024 partners and colleagues interested in the RFI detection flag validation
- Review and resolve comments received on the RFI detection flag
- Optimize detector specifications as appropriate
- Agree on RFI detection flag in ED-259B
- Results and outcomes of associated meetings will be presented in the next WG2/62 meeting scheduled in January 2025 (Toulouse/ENAC)

7.j Spoofing: Limiting the SBAS rate correction and potential spoofing impact (Todd Walter)

Summary

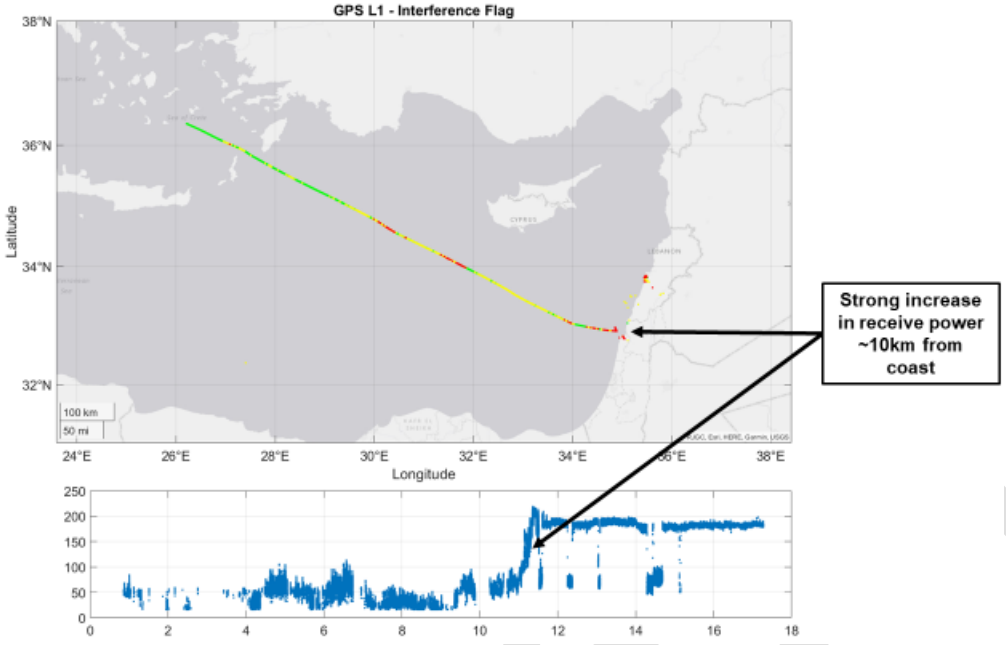
- Current correction format can be exploited by spoofers to create pseudorange errors up to several km
- Existing proposal to limit the effect of the correction rates by limiting the applied time difference
  - Could be applied by having the receiver enforce limits on Δt_D (t - t_D)
  - Could be applied by limiting Δt_D in the message
    - Requires message definition and MOPS changes
    - Frees up some bits that could be utilized for a future purpose
- Still awaiting confirmation from SBAS providers on acceptable time difference limits

Problem Overview

- Correction rate parameters could be exploited by spoofed signals to significantly increase the correction magnitude leading to significant pseudorange errors
  - MT32 corrections limited to 64 m but their range rate terms can also be configured to increase correction values to > 3 km
  - Times of applicability can be set to 12 hours difference
  - Ranging errors can be creates up to ~ 5 km
- Discussed during June EUROCAE meeting in Brussels
  - Proposal to limit the time of applicability difference to 600 seconds
  - Limits per axis magnitude to 37.5 m for the rate correction term

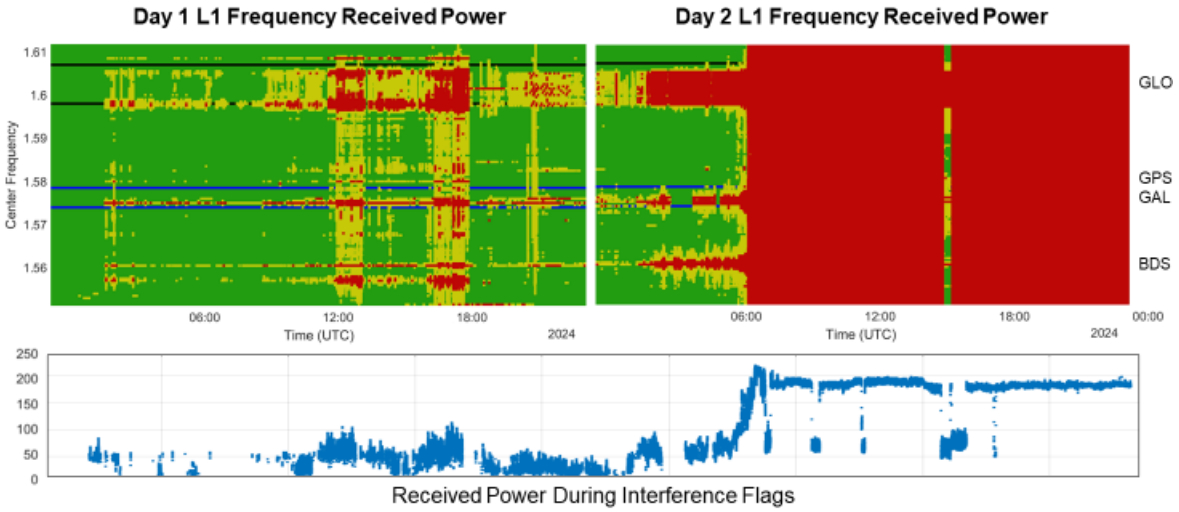
7.x Spoofing: Southeast Mediterranean Jamming and Spoofing

Jamming & Spoofing Tracking – GPS L1

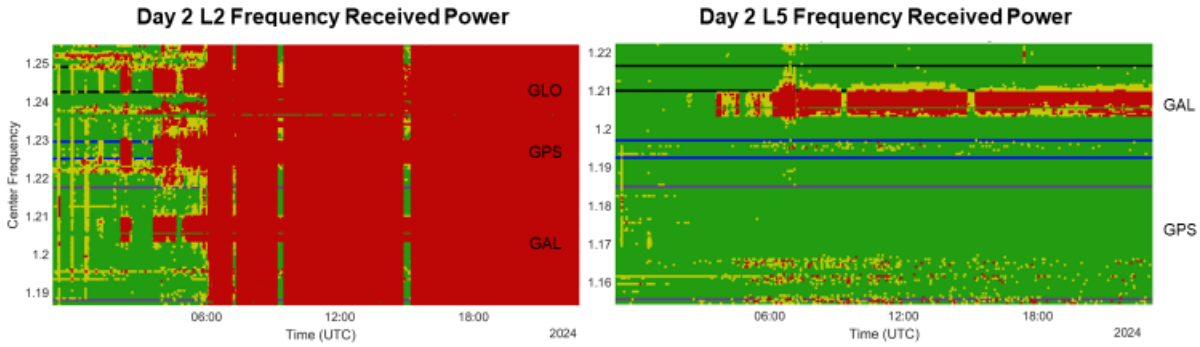


Two GNSS Rx in a container travelling from Mediterranean Sea to Israel encountered jamming in Cyprus and Jamming & Spoofing in Israel.
Can track L1 L2 L5 and also the four core constellations

Received Power – L1



Received Power – L2/L5

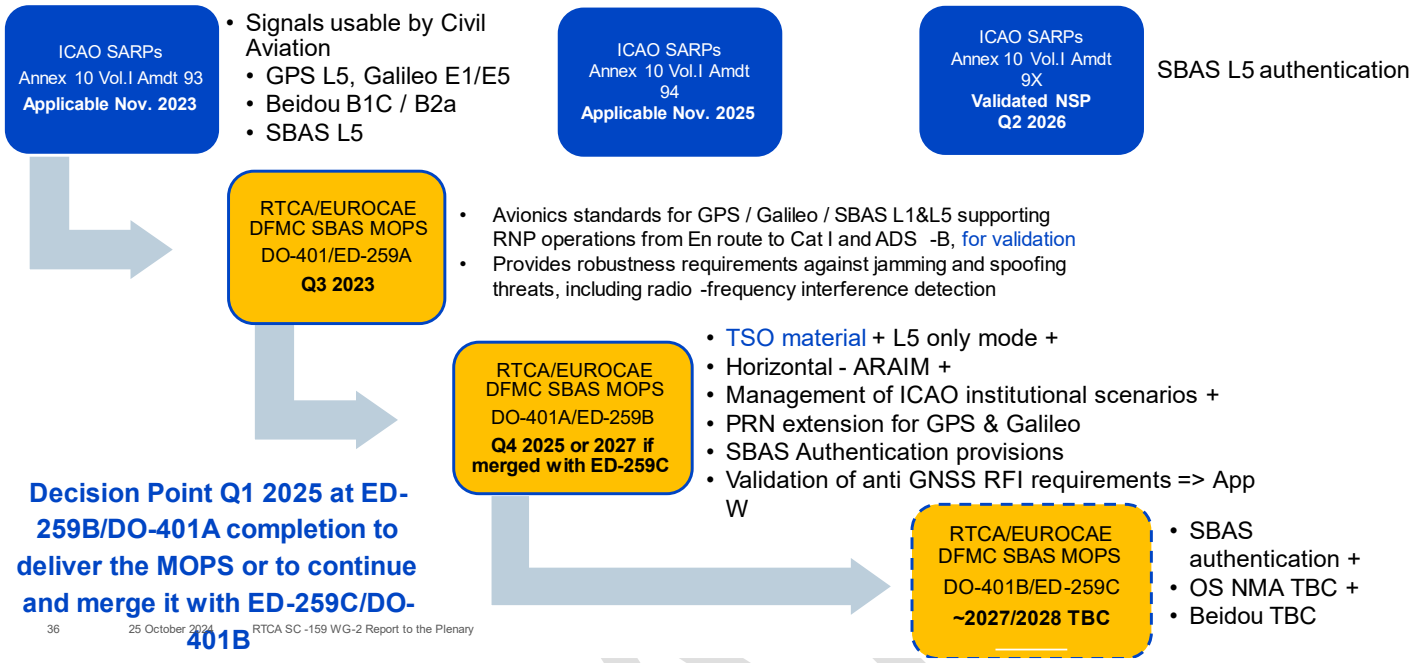


L1/L5 output a better position. Strange to have such interference at sea and the air. It could be an aircraft but static Position fix all over the place. Ephemeris near real time

8.a Review of actions (Mikael Mabilleau)

AI-72/1	Add guidance material in appendix O related to LNAV/VNAV operations, mentioning that operation covered by FAS DB will be conducted with the designated SBAS provider and that operation without a FAS DB can be supported by the equipment using any SBAS for lateral guidance. DMMS:704 needs to be adjusted accordingly.	John Foley	January 2025	Open
AI-72/2	Update DMS:802 based on the initial proposal introduced in presentation 7r providing a capability to provide position without external signal/data from the GNSS signals considered in the MOPS.	Authors' group	January 2025	Open
AI-72/3	Validate the requirements introduced in section 3.1.3.7 (reaction time for SBAS service provider designation) of ED-259B v0.4.	Authors' group	January 2025	Open
AI-72/4	Validate the requirements introduced in ED-259B v0.4 related to GPS ISD based on discussion and wording agree for the requirements proposed in presentation 7m.	Authors' group	January 2025	Open

8.c Work Plan, scope and schedule of ED-259B/DO-401A (All)



Next meeting

- **The next WG2/62 meetings are planned as follows for 2025:**
  - **January 2025, Toulouse, ENAC**
  - **March 2025, RTCA, Washington DC**
  - **June 2025, Ispra Italy**
  - **October 2025, RTCA, Washington DC**
  - **Request 3 days Monday/Tuesday/Wednesday jointly with WG-4 and EUROCAE WG-62 for next RTCA meeting in March 2025**
- **Short/midterm priorities are:**
  - **Author's group teleconferences to progress on the MOPS next revision**
  - **Appendix W Spoofing ad-hoc with a monthly meeting (Lead John Studenny)**
  - **Coordinate with ICAO NSP SAAG on SBAS authentication concepts and receiver architecture**

Mr. Azoulai finished his presentation. Mr. Studenny then commented that the hardware should be complete before this work is forwarded. The real time clock is another issue whether in the receiver or outside. Mr. Azoulai mentioned that with all this work growing in scope it probably can not all be done by 2025 to manage RFI in the MOPS. So, we look to figure this out in the January 2025 WG62 meeting which might necessitate another joint plenary to discuss all options that we need to discuss. Dr. Ligler answered that if another "off calendar" meeting for a plenary, should we have an agreed date now for process reasons. When would we want this date? Dr. Hegarty asked if there was a hurry to do this before March if we will not have the work done before the end of 2025.

Mr. Mallibeau then added that he would like to agree on a date so to have it in the books, but there might be another issue to bring forward as there might be another item that may need to be presented.
Dr. Ligler then stated that the interim plenary will be limited to what is in Mr. Azoulai's slide #37.
Mr. Mallibeau, when can you have your decision paper after your meeting? Mr. Mallibeau responded that the week after January 17th would be the plan. Mr. Barry suggested that the march PMC be considered in the selection of the date. Mr. Mallibeau responded that PMC approval may not be required. Ms. Hofmann added that if the deadline could not be made then bring this work to the March Plenary. The PMC is being more restrictive on dates, either meet them or else.
Dr. Ligler indicated that he saw the urgency to set the course and not urgency to get to the PMC.
Mr. Abduselam indicated that he did not see the need for interim plenary. Mr. Trautenburg offered that an earlier meeting to hammer out all decisions might be better than a plenary. Dr. Hegarty added that maybe this could be rescheduled during the original plenary week. Dr. Ligler offered a single day discussion option in February. February 10th ? It should be a half-day discussion start at 9am EST and run for four hours to complete work on DFMC direction for MOPS.
This completed Mr. Azoulai's report. Dr. Ligler then asked the group if they could decide on the date for the next October plenary meeting before some online in Europe would have to leave the meeting.
The group discussed and the week of October 27th – 31st should be plenary week with the 31st The day of the plenary. The group agreed to this date. Then Mr. Wichgers began the WG-4 report.

Item 5c. GPS/Precision Landing Guidance (WG-4), to include update on related ICAO/Navigation Systems Panel Activities

WG-4 Work Products per TOR

- **Initial GNSS/GBAS L1/L5 MOPS & ICD for V&V to include GPS and Galileo**
  - **Schedule per TOR is Dec. 2024, coordinated with ICAO NSP GBAS Working Group (GWG)**
    - **Dependencies: Lag initial DFMC GPS + Galileo SBAS MOPS (RTCA/ED-259A), and in parallel with ICAO NSP developing and completing baseline DFMC GBAS SARPs]**

- **Documents:**
  - **MOPS: Plan is a new document, separate from DO-253 and DFMC SBAS MOPS**
    - **(Described as Option #2 in WP06 from March 2023 meeting)**
    - **ICD: Incorporate in an update to DO-246**
- **Validated GNSS/GBAS L1/L5 MOPS & ICD to include GPS and Galileo**
  - **Schedule per TOR is Dec. 2028, coordinated with ICAO NSP GBAS Working Group (GWG)**
    - **Dependencies: Lag validated DFMC SBAS GPS + Galileo MOPS (i.e., RTCA/ED-259B) and in parallel with validated ICAO NSP validation and approval of DFMC GBAS SARPs**

Note: Schedule will not be met, lack of committed resources to develop DFMC GBAS MOPS per the TOR schedule. There is currently a more pressing demand for some of the same people resources to work other Navigation relevant issues. Propose that an updated TOR schedule be agreed at SC-159 Plenary in 1Q2025: WG-4 discussed Dec. 2026 Initial, Dec. 2030 Validated GNSS/GBAS L1/L5 MOPS & ICD (to be coordinated with ICAO NSP GWG during November 2024 meeting).

- ❑ **GBAS MOPS & ICD Maintenance – *[No new items]***
  - **DO-253D with Change 1 GPS/LAAS Airborne MOPS → 4 minor changes**
    - **3 minor issues in non-normative explanatory appendices, 4th is a clarification**
      - **1) Appendix K: Identified a small correction/clarification for the Rationale for VDB Requirements Appendix *[See WP-2 and WP-5 from October 2019 Meeting]***
      - **2) Appendix I: Identified minor update to GBAS classifications *[WP-8 from March 2020]***
      - **3) Appendix J: Identified minor clarification if ICAO SARPs change is approved to allow E_{IG} > 2.75 m *[See WP10 and WP-10a from October 2020 meeting]***
      - **4) Section 2.3.11.2: Identified minor recommended clarification for one clause of the Precision Approach Region (PAR) definition**
        - **No change to PAR, just clarification. *[See WP07 (page 3) from March 2023 meeting]***

- **No current TOR plan to update DO-253 document, but SC-159 plenary should be aware of possible future update to address changes associated with testing against FM signal evolution of hybrid analog + digital signals, future FM all digital signals, and all maintenance items.**
- **DO-246E with Change 1 GPS/LAAS ICD -- Nothing currently on Maintenance List but will update ICD along with DFMC GBAS MOPS.**
  - **Possible maintenance item with agenda item 9.a.**

❑ **Summary of the Joint Meeting WG-2/WG-4 and EUROCAE WG-62 part of the agenda is being reported in WG-2 Briefing to the SC-159 Plenary**

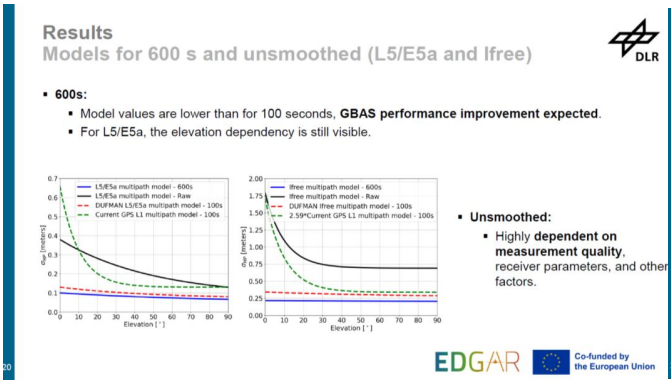
- **Meeting jointly (Monday – Wednesday) for foundational DFMC SBAS MOPS work (foundational MOPS for GBAS)**

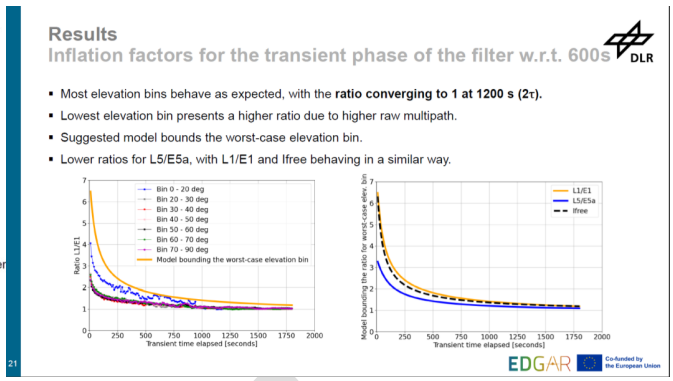
❑ **Summary of the WG-4 Portion of the Meeting is reported in this WG-4 Briefing to the SC-159 Plenary**

- **Meeting jointly for foundational DFMC GBAS MOPS development, which will use DFMC SBAS MOPS as baseline**

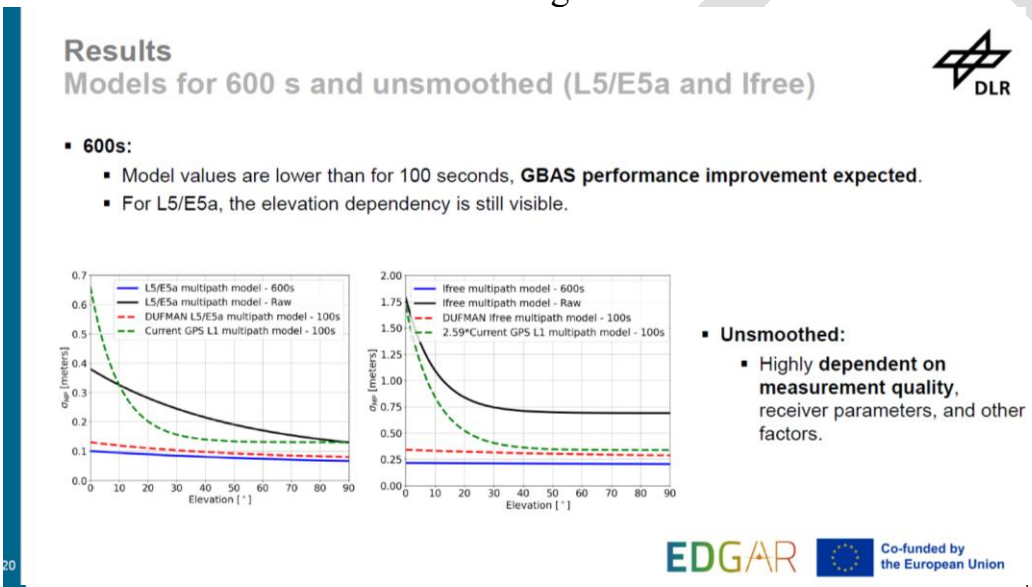
2. Updated Airborne Multipath Models for DFMC GBAS [by Maria Caamano]

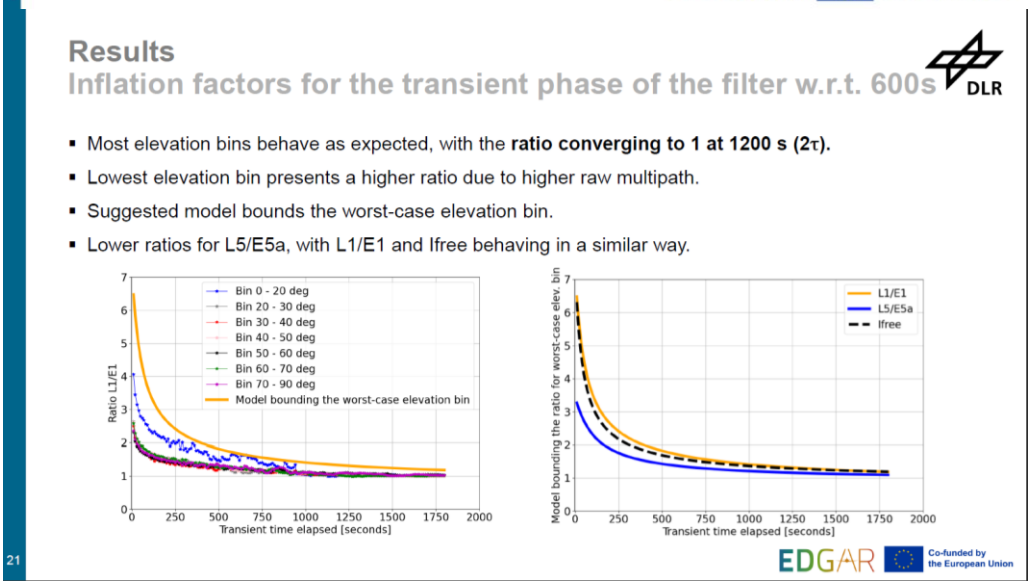
- DFMC GBAS Multipath Model (s_{mp}) updates needed for new GBAS modes
  - GAST E and fallback modes GAST C1/C2 and GAST D1/D2
  - DLR / EUSPA / EDGAR project funded this work with several key contributions
  - Extended prior DFMC multipath model results for GBAS with improved antenna calibration
  - Impact of L1/E1, L5/E5a Ifree and Dfree time-variant smoothing
  - Impact of smoothing times shorter and longer than 100s
  - Proposed models for unsmoothed and 600s-smoothed multipath
  - Inflation factors for time-variant smoothed multipath





- Feedback from WG4 for future work
  - Conservatism could be removed for the time-variant MP models by taking credit for minimum tracking time before using satellites in the DFMC GBAS solution and 5-degree satellite mask.





2. Status and Discussion of the entire ICAO Navigation Systems Panel activities with focus on the GBAS Working Group [by Tim Murphy]

- NSP Active Job Cards
  - NSP001 – Nav Roadmap;
  - NSP002 – GNSS Multi-Constellation;
  - NSP003 – SBAS Evolution;
  - NSP004 – ARAIM;
  - NSP005 – GBAS Evolution;
  - NSP006.02 – GNSS RF Interference;
  - NSP007 – Space Weather;
  - NSP 008.02 – Rationalization of Navaids;
  - NSP009.03 – APNT
- GWG Recent Activities
  - Last meeting JWGs/12 May 13-17, 2024

DFMC GBAS ad-hoc & Iono Gradient Monitoring ad-hoc continue to actively meet
WP 20 – Draft DFMC GBAS Concept Paper
IP 14 - Update on DFMC GBAS validation and the flight data collection campaign in October 2023 and March 2024
IP 23 – Extension of DUFMAN Models in Support of DFMC GBAS Standardization Activities – Planned First Steps
WP 19 - Draft DFMC GBAS Annex 10 Changes (Version 1.0)
WP 21 – GAST E Integrity Allocation
WP 22 - Interpretation on Number of Reference Receiver Indication in MT 2
WP 24 - Changes to the draft DFMC GBAS SARPs related to SBAS ranging source removal from any service types supported by Type 23 Message
WP 25 - Residual Ionospheric Uncertainty for use with GAST E
Flimsy 15 - Concepts for Time Synchronization
Flimsy 16 - Proposal for Modified Alert Limits for Operations Supported by DFMC GAST E+

- NSP GNSS Evolution - *GBAS Job Cards*
  - NSP005.04 - GBAS Evolution
    - DFMC GBAS concept and architecture definition [Q4 2024]
    - DFMC GBAS baseline development SARPs [Q4 2024] & RTCA MOPS
    - DFMC GBAS SARPs [Q4 2030], Effective Q3 2033
    - DFMC GBAS updates to GNSS Manual & GBAS Manual [Q4 2030]
    - Single Frequency GAST C & D GBAS Manual Draft [Q4 2025]
- NSP GWG Major Activities
  - GBAS SARPS Maintenance
  - Impact to Other Annexes
  - ICAO Doc 8071 update for GBAS
  - Updates to the GNSS Manual (Doc 9849)
  - Development of a GBAS Manual (on hold pending availability of resources)
  - Dual Frequency - Multi-Constellation GBAS
    - Including support for maintenance of the DFMC ConOps

3. Review RTCA Actions in ICAO NSP GBAS Working Group (GWG) DFMC GBAS Issues Matrix [by Tim Murphy]

- DFMC SARPS AD HOC (DSAH) use Issues Matrix
    - Version 0.8 now has 35 issues logged, closed 15, regular progress

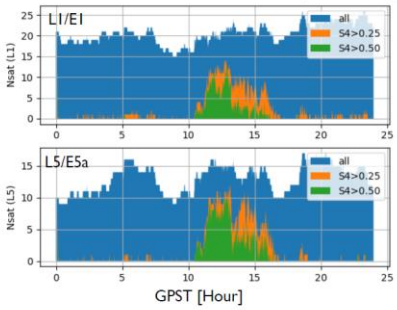
    - Significant decisions since last meeting:
        - Ground will uplink pseudorange residuals rather than raw measurements to reduce data link bandwidth
        - Two ephemeris CRCs to be uplinked in MT23 (L1&L5 ephemeris monitoring)
            - Supports DF and SF modes
        - Ground station will steer reference receiver clocks so MT23 all have same reference
            - Thus, air will not need to propagate to a common time
    - Issues for SC-159 WG4 input:
        - Need to validate MT23 minimum update rate (3 sec) to meet performance needed including CP-based propagation with integrity
        - Decide if support for non-VDB data links for other aviation communities
        - Check DO-246 for coding of MT1 Measurement Type
        - DFMC GBAS multipath model adaption to MOPS requirements
        - Decide if support for new positioning service type
        - Need receiver manufacturer thoughts on best way to specify s_{PR_gnd}

5. Additional Analysis of DFMC GBAS Flight Experiment Data [by Susumu Saito]

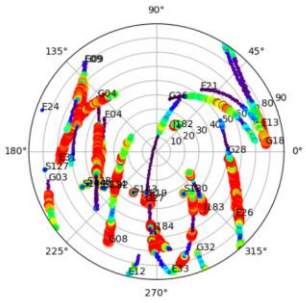
- Evaluated DFMC GBAS GAST E performance under ionospheric disturbances
    - Position errors and iono error bounds analyzed for flight/ground test data
    - Flight test for Fall 2024 was cancelled by typhoon, next experiment 1Q2025
    - DFMC GBAS solutions with SF100, DF600, IF100 were evaluated in static & airborne, quiet & disturbed conditions
    - Number of satellites low during strong scintillation → quick re-inclusion is needed
    - VPLiono with pseudorange may be too conservative, carrier bounding promising needs more work to validate
    - Next steps
    - Shorter DF/IF re-inclusion, VPLiono bounding

Ionospheric activity on 7 October

Number of satellites with scintillation (GPS+Galileo)

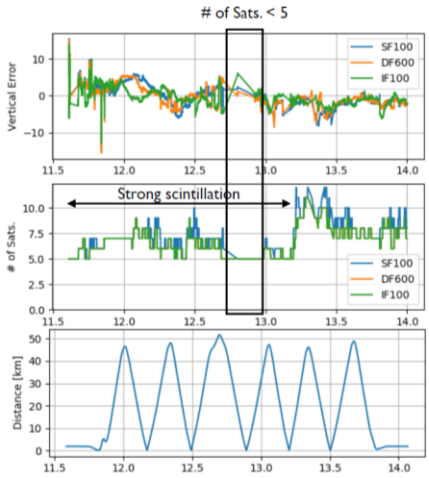


Scintillation between
1130-1400 GPST
7 October 2023



- Quiet in daytime
- Very disturbed in nighttime.

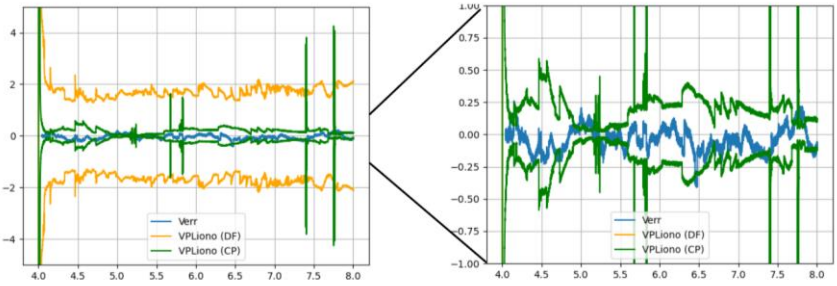
Vertical Position Error (Flight, Night, 7 October 2023)



- Bias error
  - DF600 <~ IF100 ~ SF100
- Noise
  - SF100 ~ DF600 ~ IF100

	Mean	σ	Std. relative to SF100
SF100	0.10	2.70	1.0
DF600	-0.04	2.53	0.94
IF100	-0.26	2.16	0.80

Position error and VPLiono (Static, Day, 7 October 2023)



- VPLiono with DF600 well bounds the vertical position errors including all error components.
- VPLiono with carrier-phase (CP) is of a similar magnitude as the vertical position errors including all error components.
  - VPLiono with CP is promising to bound the vertical error induced by the ionosphere.

6. DFMC GBAS MOPS Planning [by Matt Harris]

- **GBAS MOPS Planning Discussion Summary**
    - Resources still limited but work must go on to support ICAO SARPS harmonization and work plan
    - Ad-hoc group to begin 1Q2025
        - Goal is outline draft and writing assignments for review of draft material at next SC-159
        - Ad-hoc group should be aligned with ICAO DSAH/IGM ad-hoc groups
    - Update TOR to December 2026 for baseline DFMC GBAS MOPS
        - Optimistic, but best estimate to stay aligned with ICAO
    - Update TOR to December 2030 for validated DFMC GBAS MOPS
        - Aligned with ICAO job cards

7. Update on FCC Notice of Proposed Rulemaking (NPRM) Regarding FM Hybrid Analog/Digital Transmissions [by Joel Wichgers]

- December 9, 2019: National Association of Broadcasters (NAB), Xperi Corporation (Xperi), and National Public Radio (NPR) requested blanket authorization to set digital power at different levels on each digital sideband.
- August 22, 2023 – On the Federal Register: FCC Released the original Notice of Proposed Rulemaking (NPRM) regarding FM Broadcast Signals
    - Summary: NPRM proposes to permit FM stations to increase FM hybrid digital effective radiated power (FM Digital ERP) to higher levels as identified in the NPRM without the need for individual Commission authorization, as well as allowing asymmetric digital sideband operations.
- February 29, 2024 - Update: On February 29, 2024 – On the Federal Register: FCC Released additional notice for FM NPRM.
    - Summary: National Association of Broadcasters (NAB) proposes a “clarification” (really a change) to allow up to a 40% increase in the power levels of the digital sidebands without need for individual Commission authorization over the August 22, 2023 NPRM requested maximum level of -10 dBc.
    - A 40% increase represents another 1.5 dB increase because the original notice stated that the maximum power in the digital sidebands was -10 dBc and now up to -8.5 dBc.

Update

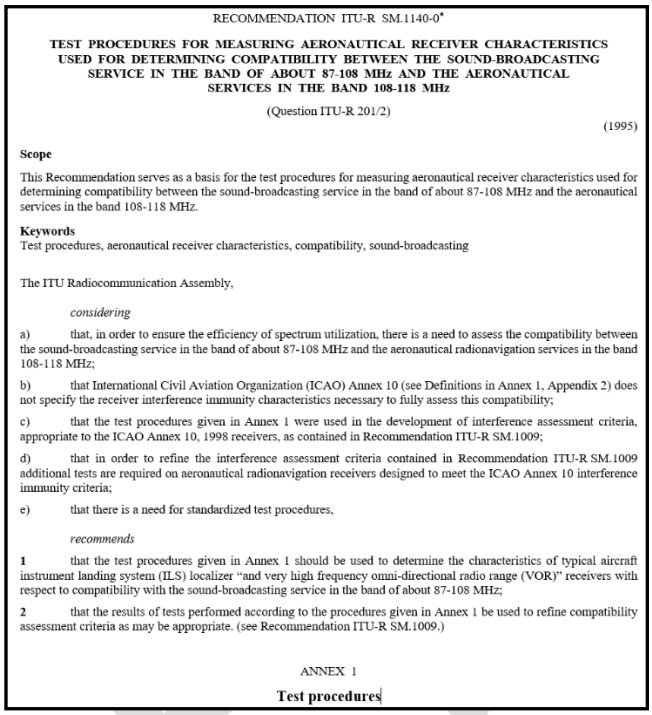
- **<u>August 20, 2024</u> – In Federal Register: FCC Released additional notice for public comment → Comments were due September 4, 2024 to be followed up with any details by September 19, 2024.**
  - Summary: The draft order adopting NPRM proposal to allow digital FM stations wishing to use asymmetric sideband operation to do so simply by notifying the Commission.
    - Except only for digital FM stations operating on Channel 300 (107.9 MHz), at the top of the FM broadcast band. Stations on Channel 300 must continue to seek experimental authorization for asymmetric sideband operation. This was proposed to be necessary (and sufficient) to protect Aeronautical Radio Navigation Spectrum ("ARNS") from possible interference.
- **<u>September 4, 2024</u>** – Initial Comments Provided by Aviation Coalition
- **<u>September 19, 2024</u> – Supplemental Letter**
  - Summary: The initial Type A2 interference test results have also identified concerns with Channel 299 (107.7 MHz) for some radios. Based on these initial test results, ongoing testing, and the need to maintain the safety of aviation operations, the **<u>Aviation Parties strongly urged the FCC to include FM Channels 296 to 299 (107.1, 107.3, 107.5, and 107.7 MHz) in the same proposed mitigation as for FM Channel 300 (107.9 MHz).</u>**
- <u>September 26, 2024</u> – FCC Adopted Aviation Coalition Recommendations
- <u>October 21, 2024</u> – FCC Federal Register Notice that the Final Rules will become effective on November 20, 2024.

8. Update on Test Procedures Activity & Testing of VHF Nav. Band Avionics with FM Transmissions including both Analog & Hybrid Analog/Digital Signals [by Joel Wichgers]

Working update to ITU-R Doc for Testing compatibility of VHF Nav. With FM Broadcast Signals

Original SM.1140

- Developed and approved in 1990's
- ITU-Recommendation for Testing Compatibility between Sound Broadcasting Services in band of about 87 to 108 MHz and the Aeronautical Navigation Services in 108 to 118 MHz band.
- Recommends specific test procedures for determining interference immunity characteristics of ICAO Annex 10 1998 ILS localizer (LOC) and VOR receivers from Sound (FM) broadcasting stations.
- Test procedures were originally developed by Radiocommunication Task Group studying aeronautical/ broadcasting compatibility and were used in the bench testing of the ICAO Annex 10 1998 receivers at the Federal Aviation Administration (FAA) Technical Center (Atlantic City, New Jersey, United States of America) in 1993-94. Additional testing / cross-check tests conducted by other organizations.



RECOMMENDATION ITU-R SM.1140-0*

TEST PROCEDURES FOR MEASURING AERONAUTICAL RECEIVER CHARACTERISTICS USED FOR DETERMINING COMPATIBILITY BETWEEN THE SOUND-BROADCASTING SERVICE IN THE BAND OF ABOUT 87-108 MHz AND THE AERONAUTICAL SERVICES IN THE BAND 108-118 MHz

(Question ITU-R 201/2)

(1995)

Scope

This Recommendation serves as a basis for the test procedures for measuring aeronautical receiver characteristics used for determining compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band 108-118 MHz.

Keywords
Test procedures, aeronautical receiver characteristics, compatibility, sound-broadcasting

The ITU Radiocommunication Assembly,

considering

a) that, in order to ensure the efficiency of spectrum utilization, there is a need to assess the compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical radionavigation services in the band 108-118 MHz;

b) that International Civil Aviation Organization (ICAO) Annex 10 (see Definitions in Annex 1, Appendix 2) does not specify the receiver interference immunity characteristics necessary to fully assess this compatibility;

c) that the test procedures given in Annex 1 were used in the development of interference assessment criteria, appropriate to the ICAO Annex 10, 1998 receivers, as contained in Recommendation ITU-R SM.1009;

d) that in order to refine the interference assessment criteria contained in Recommendation ITU-R SM.1009 additional tests are required on aeronautical radionavigation receivers designed to meet the ICAO Annex 10 interference immunity criteria;

e) that there is a need for standardized test procedures,

recommends

1 that the test procedures given in Annex 1 should be used to determine the characteristics of typical aircraft instrument landing system (ILS) localizer "and very high frequency omni-directional radio range (VOR)" receivers with respect to compatibility with the sound-broadcasting service in the band of about 87-108 MHz;

2 that the results of tests performed according to the procedures given in Annex 1 be used to refine compatibility assessment criteria as may be appropriate. (see Recommendation ITU-R SM.1009.)

ANNEX 1

Test procedures

Updates to SM.1140

1 Background and introduction

This original Recommendation specifies test procedures for determining the interference immunity characteristics of ICAO Annex 10 1998 ILS localizer and VOR receivers with respect to Type A1, A2, B1, and B2 interference from broadcasting stations transmitting analog radio signals. These test procedures were developed by Radiocommunication Task Group 2/1 studying aeronautical/broadcasting compatibility and were used in the bench testing of the ICAO Annex 10 1998 receivers at the Federal Aviation Administration (FAA) Technical Center, Atlantic City, New Jersey, United States of America in 1993-94 and subsequent cross-check tests conducted by other organizations.

Updates to the original Recommendation are in the process of being drafted to address changes in the test procedures to also test the compatibility of ILS and VOR receivers with respect to Type A1, A2, B1, and B2 interference from stations transmitting In-Band On-Channel (IBOC) hybrid analog radio and digital radio signals simultaneously. Additionally, test procedures are being developed to test Ground Based Augmentation System (GBAS) VHF Data Broadcast (VDB) receivers with respect to Type A1, A2, B1, and B2 interference from stations transmitting either analog or IBOC hybrid signals.

Test Procedures Gaps being Filled

- **Address testing with the hybrid FM signals**
  - FM broadcast signals were analog signals when SM.1140 was originally developed. FM broadcast signals have evolved to include hybrid analog and digital signals. Future FM broadcast signals are expected to include all digital signals.
- **Currently did not address GBAS VHF Data Broadcast (VDB)**
  - The GBAS VDB was not developed / standardized when SM-1140 was originally developed.

Initial (Limited) Testing Has Been Completed – Additional Testing In Process

- **Draft Test Procedures Document Available for Review and Comment (Work in Progress), but being matured by initial equipment manufacturer testing**
- **Initial Testing is underway, and test results are being shared by manufacturers who participate in the Ad Hoc working group**

9.a. Measurement Type Field in LAAS/GBAS Message Type 1 [Joel Wichgers / Yi Ding / Vignesh Krishnan]

ICAO DFMC SARPS ad-hoc wishes to use alternate codings for the 'Measurement Type' field for DFMC GBAS (GAST C/D only zeros)

Receiver manufacturers were surveyed to confirm that future use of new coding of that field would be backward compatible.

At least one manufacturer reported testing revealed that non-zero values would cause a problem for existing receivers.

A potential way forward was identified and discussed (change Message Type 1 to only allow Measurement Type field to be coded as "000", and uplinking of corrections for other Measurement Types would need to be coded in another Message Type.

Further investigation is planned to see if this potential way forward addresses the issue. If selected, this would require changes to the LAAS ICD and ICAO SARPs.

Table 2-12: Format of Message Type 1

Data Content	*Bits Used*	*Range of Values*	*Resolution*
Modified Z-count	14	0 – 1199.9 sec	0.1 sec
Additional Message Flag	2	0 – 3	1
Number of Measurements	5	0 – 18	1
Measurement Type	3	0 – 7	1
Ephemeris Decorrelation Parameter (Notes 2, 5)	8	0 – 1.275×10^{-3} m/m	5×10^{-6} m/m
Ephemeris CRC (Notes 2, 5)	8 (most significant byte) (Note 6)	-	-
	8 (least significant byte) (Note 7)		
Source Availability Duration (Notes 4, 5)	8	0 – 2540 sec	10 sec
For N Measurement Blocks:			
Ranging Source ID	8	1 – 255	1
Issue of Data (IOD)	8	0 – 255	1
Pseudorange Correction (PRC)	16	±327.67 m	0.01 m
Range Rate Correction (RRC)	16	±32.767 m/s	0.001 m/s
σ_{pr_gnd} (Note 3)	8	0 - 5.08 m	0.02 m
B_1 (Note 1)	8	±6.35 m	0.05 m
B_2 (Note 1)	8	±6.35 m	0.05 m
B_3 (Note 1)	8	±6.35 m	0.05 m
B_4 (Note 1)	8	±6.35 m	0.05 m

10. Work Plan Discussion

- **Resources**
  - Overall Lack of Organizations / Companies providing sufficient committed resources
  - Need committed volunteers to develop
  - Need MOPS authors team leader
- **Schedule**
  - Will not meet December 2024 draft DFMC MOPS schedule. likely for at least 2 years in the future if resources are added now.

This concluded Mr. Wichers briefing. The group took a short break to recognize Mr. Trautenburg and Ms. Hofmann for their work with many of the RTCA committees over the years. Dr. Hegarty then Presented a memento book to Ms. Hofmann. She expressed gratitude and thanks for all the relationships and accomplishments made. Mr. Kalyanaraman then began his briefing.

Item 5d. GPS/Interference (WG6), to include update on related ICAO/Navigation Systems Panel activities

WG6 – Status
Agenda

1. DME – JTIDS spectrum compatibility
2. Update of DME reply rate statistics
3. Update of RFI Environment reflecting PRN expansion
4. Update on LEO PNT impacts to civil aviation GNSS
5. Analysis of GNSS jamming / spoofing threats
6. DO-292A closeout

Update of DME reply rate statistics

- EUROCONTROL and ENAC received data from SKEYES Belgium containing interrogation and replies counts from 12 SKEYES operated DMEs
- DME Interrogation rates (as a moving average over 5-min intervals)
- Max of 1393 ppps since 9 dec 2018 18h00 for 12 DMEs
- No set of DME reach their peak simultaneously at the same day
- Values for other DMEs at time of peak of busiest are far from peak values of these DMEs
- Using 2700 ppps for all DMEs in Europe in GNSS/DME compatibility studies therefore represents an extremely unlikely situation
- It is therefore proposed to reconsider the value of the 2700 ppps for all DMEs.
- We propose to consider PRF=1500 ppps **simultaneously** for all 95 DMEs in Europe viewed at Europe hot-spot as an over bound for DME / GNSS L5/E5a worst case compatibility analysis

GPS and Galileo PRN expansion

- Plan to consider a number of GPS and GALILEO satellites greater than 30 SVs:
- Orbiting and transmitting GNSS signals
- Processed by the DFMC SBAS receiver
- Previous work on this topic had consisted in computing:
  - The new IGNSS for victim GPS L5, GPS L1 C/A, GALILEO E5a and GALILEO E1 for several hypothetical options of increase of IGNSS (ex: +3 dB) or generic orbital extensions (contribution from Chris Hegarty)
  - The new C/N0 link budget margin for GALILEO E5a and GALILEO E1 OS processing channels.
  - Link margin for GPS not updated because the increase of IGNSS would cause negative link margins and way forward identified is the hope to update the minimum elevation angles to be considered.
  - Issue is that the usable PRNs may be limited to the PRNs in the SBAS mask, and this may not include the PRNs that would provide the best margin.
- EUSPA has provided a 36 Galileo SV almanac for reference and analysis
- Hamza Abdusalem from FAA is working on providing an updated almanac that reflects GPS PRN expansion

- Work plan to analyze impact of PRN extension to the GNSS C/N0 link budgets within WG6:
- Cross-correlations from new PRNs if needed
- Minimum Elevations, Gagg
- IGNSS
- Determine new Acquisition, Tracking, Demodulation C/N0 link margins
- Work has begun regarding point 2 and 3 for GALILEO 36SV constellation. Will reevaluate the details for GPS once we obtain the updated almanac for GPS.

LEO PNT impacts to civil aviation GNSS

- Several RNSS LEO PNT projects with an L-band component are under consideration:

1. SATNET LEO Augmentation Navigation System (504 SVs @ 1150 & 1175 km, ITU Filing: 2020)
- Centispace, 162 SVs @ 1100 km probably included in SATNET (info to ITU: 2018 ?)
2. Xona Pulsar (258 SVs @ 1080 km, US Filing USASAT-NGSO-12 to ITU requesting orbit/band: 2023)
3. Synchrocube (24 SVs @ 550 km, ITU Filing: 2023)
4. NSAT01 (96 SVs @ 800 km, ITU Filing: 2019)
5. EU-LNAV (263 SVs @ 1200 km) NEW

6. Jukebox (info to ITU: 2019 ?)
7. **Geesat (240 SVs @ 800 km, info to ITU: 2019)**
8. **COSMIC-2 (12 SVs @ 535 km, although R only in ITU SNL)**
9. **CSN-V4/5/6 (16x24 @ 453 km+15x24 @ 478 km+20x20 @ 503 km=1144 SVs)**
10. **TARD-1S (199 SVs @ 1023 km)**
11. **PAX-1 (1160 SVs @ 550 km)**
12. **UK, Finland, Japan ?**

- **+ other European Union initiatives on LEO PNT ?**
- These projects, which may contain a significant number of SVs to provide a global service, may impact the airborne civil aviation receiver $(C/N_0)_{eff}$ link budget..
  They may also impact the EPFD as per ITU Res 609, not discussed here

LEO PNT - Safety margin and apportionment

Margins to be taken on the tolerable I_0 component due to L-band LEO PNT

- Some or all of the L-band LEO PNT constellations may not have coordinated operation with civil aviation.
- Need margin (6 dB) to cover known unknowns (ex: SV antenna gain, useful signal variations, signal purity, SV power control, constellation variations), and unknown unknowns.
- This margin could be reduced if more confidence on a LEO PNT project is brought to the civil aviation community.
- For derivation of an individual emission tolerance threshold, as several other non-aeronautical interference components may exist in the band, an apportionment factor may be needed.
- Therefore, an apportionment ratio Q in dB is used in this presentation when defining an individual threshold.
- Q could reflect at least 4 (6dB) and maybe 5 -10 RFI sources (up to 10 dB)

LEO PNT – Feedback from FSMP WG19 (July 2024)

Initial FSMP WG19 (July 2024) feedback:

- ITU-R M.1905 specifies interference thresholds from systems which are **NOT** RNSS systems to RNSS systems. Possible to suggest modifications to ITU-R M.1905 so that these thresholds also apply to non-aeronautical RNSS ?**-> Discuss at NSP JWGs/13 Nov 2024**
- FSMP suggests that NSP provides a documentation of the predicted interference from LEO PNT to civil aviation GNSS receivers for the intention of FSMP and further ITU WP4C, so that ITU WP4C redacts a report on these elements by itself **-> Discuss at NSP JWGs/13 Nov 2024**
- FSMP WG20 will consider sending a liaison statement to ITU WP4C drawing attention from ITU to this problem of LEO PNT vs civil aviation GNSS **-> Discuss at NSP JWGs/13 Nov 2024**

LEO PNT - RFI impact of L-band RNSS LEO PNT constellations on civil aviation GNSS Rx

- More than 11 L-band RNSS LEO PNT projects identified with up to a total of 4000 satellites at altitudes 530 km - 1200 km, radiating signals potentially affecting the GNSS L1/E1 and/or GNSS L5/E5a bands.
- Civil aviation tolerance thresholds for this interference can be drawn from ICAO/RTCA standards (RFI mask) or from ITU recommendations
- Each of these L-band LEO PNT projects exceeds these thresholds when accounting for safety margin and/or apportionment factor
- Aggregate noise from L-band LEO PNT projects exceeds these thresholds when accounting for safety margin and/or apportionment factor
- RTCA/EUROCAE, ICAO actions:
  - Conduct research to update C/N0 link budgets to try and provide less extreme C/N0 bounds (GNSS receiver front-end model, JTIDS/MIDS scenarios, DME/TACAN propagation models, GNSS Receiver Implementation Losses)
  - Try and draw attention from administrations of LEO-PNT projects and try to provide them with more guidance on the way to compute impact to civil aviation GNSS receiver and its tolerance thresholds

- Elaborate report of predicted impacts from L-band LEO PNT projects to civil aviation receivers, to be submitted to ITU WP4C

Analysis of GNSS jamming / spoofing threats

ENAC proposes to contribute to the analysis of the GNSS spoofing situations by:

- Contributing to the GNSS antenna/RF/signal processing/observables prediction
- Helping characterize the Pmd determination for GNSS receiver consistency checks, local RAIM, ARAIM
- Helping characterize the integrity risk for the PVT solution and the recovery performance
- This evaluation could further help towards:
  - Determination of expected spoofer detector Pmd
  - Determination of continuity performance
  - Definition of test cases which are bounding the other cases of the scenario
- ENAC suggests that the signal processing and the integrity analyses could be started at the minimum from the 6 test cases in ED259A 5.3.7 (Integrity in presence spoofing)
- ENAC started working on that analysis in the ground repeater case (S1) and in the on-board repeater case (one additional potential case of S7)

Dr. Kalyanaraman concluded the WG-6 briefing and commenced the WG-7 briefing.

Item 5e. GPS/Antennas (WG7)
DO-373A FRAC

- FRAC closed on 3Oct2024
- Called two WG7 meetings ahead of SC-159 plenary to address FRAC comments.
- 34 comments: 1 Non concur, 1 high, 14 medium, 8 low, 10 editorial
  Addressed all High, Medium, and Low
- Discussed with stakeholder who provided the sole Non concur
  - WG7 lead to communication solution to address non-concur to stakeholder via mail.
- Goal: Close out implementation of FRAC comments by first week of Nov and share updated document with RTCA by 8 Nov2024**.**

Dr. Hegarty then interrupted Dr. Kalyanaraman with a question on the nature of the non-concur. Dr. Kalyanaraman explained that he had discussions with the author of the non-concur and hopefully resolved the comment. Ms. Hofmann stated that getting this document to the RTCA by 8th of November would ensure that it makes to the December PMC. **Dr. Ligler queried the committee if they agreed with Dr. Kalyanaraman's plan to get the document done and the commenters issue resolved so that we recommend that it go forward to the PMC. The committee agreed to the proposal.** The briefing continued.

Future CRPA Standardization

- WG7 discussed elements and scoping for CRPA standardization, and a few high-level questions arose:

1) What is our gating function to start developing a GNSS CRPA standard?
    1) Do we need to wait for EAR updates/alignment after the ITAR updates ?
    2) Do we also need to wait for European rules (EU common military list – dual use list) to align with any ITAR updates here in the US (especially re: dual use of CRPA's) ?
    3) What about regulations in other countries ?
2) Do we want to accept the ability to conform to current ITAR regs and standardize multi element antennas that may still be allowed under the current ITAR regimen (thus not waiting for the ITAR update to occur)
    1) Question for FAA: What CRPA antenna configs will be allowed to TSO under the current ITAR rules ?
3) Do we want to allow for applique solutions that support nulling only architectures ?
4) Do we only standardize CRPA beam steering architectures (i.e., the more capable solution that allows for better availability and integrity) ?
    1) Do we need to specify pre vs post correlation beamforming ?

Mr. Abduselam offered to Dr. Kalyanaraman that the FAA does not have an answer as to how much work can be done under ITAR as to development of a CRPA antenna. He assured all that the FAA would work to get those answers. Dr. Ligler asked if we have already discussed the regulatory side with Mr. Abduselam, what do we consider if ITAR is relaxed? How much can we do? Mr. Abduselam indicated that it is difficult since we do not know what the change(s) could be. Dr. Hegarty offered that the group should wait to get the ITAR update. There are some good changes that will come from this work but we need to see how far we can go to determine the flexibility in design. Ms. Hofmann also reminded the group that the DO-373 document needs to be into RTCA by noon November 4th or it will not be on the agenda for December PMC.

Agenda item 6. Discussion Terms of Reference

Dr. Ligler asked the group as to what to do with the ToR for the December PMC meeting. He Offered that we should let them know that there are changes coming. This was based on what was heard in this plenary. Other things that we know we can provide should now be in the draft changes. Ms. Hofmann then went over the draft changes to the ToR.

TERMS OF REFERENCE

Special Committee SC-159
Navigation Equipment Using the Global Navigation Satellite System (GNSS)
(Version 23)

SC LEADERSHIP:

Position	Name	Affiliation	Telephone	Email	Change
Co-Chair	Christopher Hegarty	The MITRE Corporation	781-271-2127	chegarty@mitre.org	
Co-Chair	George Ligler	Texas A&M University	979-485-2453	gtligler@tamu.edu	
Government Authorized Representative	Hamza Abduselam	FAA/AIR-626B	202-267-8625	Hamza.abduselam@faa.gov	
Secretary	Wes Googe	American Airlines	336-830-4120	wes.googe@aa.com	

BACKGROUND:
Since it was established in 1985, RTCA SC-159 has produced and maintained a suite of minimum operational performance standards (MOPS) and minimum aviation system performance standards (MASPS) for aviation equipment using the Global Positioning System (GPS) and its augmentations, specifically aircraft-based (ABAS), ground-based (GBAS), and satellite-based (SBAS) augmentation systems, using a single GPS signal, the GPS coarse/acquisition (C/A) code that is modulated on the link 1 (L1) carrier frequency of 1575.42 MHz. Similarly, the International Civil Aviation Organization (ICAO) has produced various aviation and equipment standards for GPS and its augmentations. All of these standards are in global use today.
The world is entering a new era of the Global Navigation Satellite System (GNSS) with new constellations and a variety of new, civil, safety-of-life signals. Consideration for use requires that the carrier frequencies be at 1575.42 MHz and at 1176.45 MHz with a usable signal bandwidth of no more than +/-12MHz around the carrier frequency. Other conditions may apply, such the signal being open and being supported by the service provider for safety-of-life use.
The current GNSS status is that GPS is presently being modernized, and the constellation is being populated with three new civil signals (L5, L2C, and L1C) on multiple frequencies with three of the four end-state civil signals (L1 C/A, L5, and L1C) being located within bands allocated for aeronautical radio navigation services (ARNS).

SBASs, such as the Wide Area Augmentation System (WAAS) in North America, are evolving to support dual-frequency user equipment. Additionally, other GNSS core constellations have been deployed (Russia's GLONASS) or are being deployed (Europe's Galileo and China's BeiDou).
ICAO's Navigation System Panel (NSP) is updating Standards and Recommended Practices (SARPs) contained within Annex 10 to the International Convention on Civil Aviation to incorporate GPS and GLONASS modernization as well as the new core constellations. Aviation equipment standards are/will be required for safety-of-life use. A GPS/GLONASS L1 MOPS was produced and adopted in 2017 as a first step towards standardization of multi-constellation equipment.

PRODUCT DELIVERABLES:

Product	Description	FRAC Completion Due Date*	Projected Publication Date**	Change
DO-401A/ED-259B ***, ****	Update to GPS/Galileo/SBAS MOPS for dual-frequency equipment	December 2025*****	March 2026	
BeiDou Internal Report	Internal Report on BeiDou System and BeiDou SBAS	March 2025******	June 2025	White Paper September 2024
GNSS(GBAS) L1/L5 MOPS and ICD***	Initial MOPS and ICD for Verification and Validation Validated GPS/Galileo/GBAS MOPS and ICD for dual-frequency equipment.	December 2026 December 2030	March 2027 March 2031	December 202 December 2028

*Note: Final Review and Comment (FRAC) Completion Due Date refers to the date that the committee plenary approves the document after completing the FRAC Process. SCs should submit the final document at least 45 days before the PMC meeting where it will be considered for approval.
**Note: Projected Publication Date refers to the date that the item will be approved by the PMC and officially published by RTCA.
*** Requirements for core constellations in addition to GPS and Galileo will be dependent upon multiple prerequisites as discussed in the Specific Guidance Section below. Additionally, in the case of the GNSS (SBAS or GBAS) L1/L5 MOPS, constellation providers will be advised to provide final needed technical information at least two-years prior to the completion of the Updated MOPS in order to have their constellations included in the MOPS. This includes the official set of user interface definition, technical and performance information for the core constellations, technical service provisions for H-ARAIM, interference environment (RTCA DO-235C, DO-292A) and multi-constellation SBAS.
**** Operations targeted for this MOPS include, GPS / Galileo / SBAS L1&L5 supporting RNP operations from en route to Cat I and ADS-B, for certification, robustness requirements against jamming and spoofing threats, including radio-frequency interference detection. The MOPS will include integrated DO-229F requirements for class Beta, Delta and Gamma receiver classes, DFMC SBAS E1/L1/E5a/L5 requirements, including DF SBAS-Ranging, H-ARAIM requirements, GPS & Galileo L5 only modes, management of ICAO Institutional scenarios, PRN extension for

GPS & Galileo satellites.
***** SC-159/WG-62 is considering additional requirements including SBAS authentication, Galileo OS NMA, BeiDou as a core constellation, GPS L1C, and V-ARAIM. These requirements may be addressed in a future revision or through an extension of the delivery date of DO-401A/ED-259B.
****** This is the completion date for the Internal Report and not a FRAC completion date (FRAC is not required for this internal report). This will be developed jointly with EUROCAE WG-62.

The highlighted changes in the Product Deliverables table were approved in the plenary session as required by RTCA Process. The title of the table and the additional column to indicate Publication Date is an RTCA Template change and not open to committee discussion.
Notes below the table also had changes by SC-159 which are also highlighted.

The Yellow Highlighted material above identifies changes to ToR submitted to PMC for approval.

Agenda item 7. Action Item Review

Dr. Ligler disposed of this item as complete as there were no action items.

Agenda item 8. Assignment/Review of Future Work

There were no assignments or future work

Agenda Item 9. Other Business

Mr. Studenny asked the group if they should look at opening work in DO-384 to consider Spoofing. Dr. Hegarty said that more discussion was needed before reactivating WG-2C. Dr. Ligler added that this item should be added to the March 2025 plenary. Mr. Krishnan asked Mr. Studenny if he thought Inertial Manufacturers should participate in his Ad-Hoc WG-2 efforts. He responded that he saw that a natural collaboration between WG-2c and the Ad-Hoc group.

Agenda Item 10. Date and Place of Next Meeting

Dr. Ligler reviewed the dates for the next fall plenary meeting. SC-159 will meet the week of 27th of October 2025 with the plenary meeting being held on the 31st.

Agenda Item 11. Adjourn

Dr. Ligler thanked all participants and adjourned the meeting at 1:15 pm.

CERTIFIED as a true and accurate summary of the meeting.

-S-
Dr. Christopher Hegarty
Co-Chairman

-S-
Dr. George Ligler
Co-Chairman

-S-
Wes Googe
Secretary