

Summary of the One Hundred and Fourth Meeting

Special Committee 159

Navigation Equipment Using the Global Navigation Satellite System (GNSS)

The one hundred and fourth meeting of SC-159 was held October 4, 2019 at RTCA Headquarters, 1150 18th Street NW, Suite 910, Washington, D.C. 20036. The attendees were the following:

NAME	COMPANY
Christopher Hegarty (Co-Chairman)	The MITRE Corporation
George Ligler (Co-Chairman)	Project Management Enterprises Inc.
Karan Hofmann (Program Director)	RTCA
Barbara Clark (GAR)	Federal Aviation Administration (FAA)
John Savoy (Secretary)	Honeywell International, Inc.
NAME	COMPANY
Ken Alexander	Federal Aviation Administration (FAA)
Doug Arbuckle	Federal Aviation Administration (FAA)
Laurent Azoulai	Airbus
Denis Bouvet	Thales Group
Mats Brenner	Honeywell International, Inc.
Christina Clausnitzer	Federal Aviation Administration (FAA)
Jed Dennis	NAVTAC
Pierre Durel	European GNSS Agency
John Foley	Garmin Ltd.
Thomas Googe	American Airlines, Inc.
Matt Harris	The Boeing Company
Sai Kalyanaraman	Rockwell Collins, Inc.
Vladimir Latev	Universal Avionics Systems Corp.
Kuniyuki Matsuda	Japan Radio Air Navigation Systems Association
Lada Semina	NNC Consulting LLC
Khambrel Simpson	The MITRE Corporation
John Studenny	Easterline CMC Electronics
Monica Vafiades	U.S. Air Force
Joel Wichgers	Collins Aerospace

The agenda for the meeting follows:

1. Introductory Remarks: RTCA, GAR and Co-Chairs
2. Approval of Summaries of Previous Meetings

- a. One Hundredth Third Meeting held March 8, 2019 (RTCA Paper No. 211-19/SC159-1079)
3. Final Review and Comment (FRAC) activities
 - a. DO-235C (WG-6) Release for FRAC
 - b. DO-292A (WG-6) Release for FRAC
4. Review Working Group (WG) Progress and Identify Issues for Resolution.
 - a. GPS/WAAS (WG-2)
 - b. GPS/GLONASS (WG-2A)
 - c. GPS/Inertial (WG-2C)
 - d. GPS/Precision Landing Guidance (WG-4)
 - e. GPS/Interference (WG-6)
 - f. GPS/Antennas (WG-7)
5. Review of EUROCAE Activities and Discussion of Joint Activity with EUROCAE on a Dual-Frequency, Multi-Constellation GNSS Receiver MOPS
6. Update on ICAO/Navigation Systems Panel
7. Discussion of Terms of Reference Updates
8. Action Item Review
9. Assignment/Review of Future Work
10. Other Business
11. Date and Place of Next Meeting
12. Adjourn

Barbara Clark, Federal Aviation Administration (FAA), was the Government Authorized Representative for this meeting.

Agenda Item 1. Chairman’s Introductory Remarks.

- At the suggestion of Co-Chairman Chris Hegarty, attendees introduced themselves.
- Karan Hofmann, Program Director of RTCA, noted that RTCA is NOT a federal advisory committee but that meetings are conducted in strict accordance with U.S. anti-trust laws. She discussed RTCA’s proprietary references policy and committee participation membership policy. Ms. Hofmann noted that this Advisory Committee meeting is open to the public, that notice of the meeting was published online but not in the Federal Register as had been done previously, and that members of the public may present written or oral statements with the permission of the committee chairmen and program director.

Agenda Item 2. Approval of Summaries of Previous Meetings.

- a. The summary for the 103rd meeting, RTCA Paper No. 211-19/SC159-1079, was approved.

Agenda Item 3. Final Review and Comment (FRAC) activities.

- a. DO-235C (WG-6) Release for FRAC

Sai Kalyanaraman, chairman of working group 6, indicated that DO-235C was still not ready to enter FRAC. He requested an extension with an intent to complete the FRAC period prior to the upcoming March meeting. The Plenary meeting approved this extension.

- b. DO-292A (WG-6) Release for FRAC

DO-292A is also delayed and will not be ready to enter FRAC until after the next (March) SC-159 plenary. Dr. Kalyanaraman asked the committee to consider extending the deadline for this document to the October 2020 plenary. The Plenary approved this extension. Plenary approval to enter FRAC can be taken up at the March 2020 SC-159 plenary.

Agenda Item 4a. Review GPS/WAAS (WG 2) Progress and Identify Issues for Resolution.

Laurent Azoulai and John Studenny, co-chairmen of Working Group 2, discussed the progress made by that group during the week.

- Working groups 2 and 4 met jointly Monday – Thursday (September 30 – October 2) to make progress on the new dual frequency, multi-constellation MOPS.
- Jason Burns informed the joint working group on the current status of the WAAS program.

- SES-15 (GEO 6) completed WAAS integration on June 15, 2019. Galaxy 15 (CRW) was removed from WAAS on July 25, 2019. GEO 7 (Intelsat at 125W) will be integrated into WAAS by September 2021.
- There are now over 125,000 WAAS-equipped aircraft in the NAS and 4703 WAAS LPV/LP procedures.
- Government Fiscal Years 2020 and 2021 will also see continued definition of Dual Frequency Operations requirements and alignment with the GPS modernization schedule
- Pierre Durel briefed the working groups on the status of the EGNOS program.
 - EGNOS service is currently provided by two GEOs: SES-5 and ASTRA-5B. Inmarsat 4F2 serves as a back-up and E5WB is ready for launch.
 - Safety of Life SDD version 3.3 was published on March 26, 2019.
 - There are now 336 LPV and 196 LPV-200 procedures in Europe.
 - EGNOS v.3.2 is scheduled to offer DFMC GPS and Galileo services in the mid 2020's
- Kuniyuki Matsuda described for the working groups the current status of the MSAS program.
 - MSAS is currently providing dual PRN operation with MTSAT-2.
 - From 2020 – 2023, MSAS V2 will provide single PRN operation with the QZS-3 GEO. And subsequently V3 LPV service with three QZSS GEOs (QZS-3, -6, and -7). V4 will provide DFMC service.
- Pierre Durel provided status on the work by the ICAO DFMC SBAS SARPs Subgroup (DS2)
 - The DS2 group aims to produce SARPs amendments for SBAS L5 and propose them to NSP for approval by October 2020.
 - Progress has been made on various topics (e.g., parameter checks, compatibility with antenna MOPS, code carrier coherence, time-to-alert, receiver design constraints) through coordination with the SC-159/WG-62 DFMC Author's Group.
- Hamza Abduselam informed the group about proposed changes to IS-GPS-200K and the disposition of comments from the aviation community.
- Barbara Clark and Hans Trautenberg led a discussion on DFMC products including whether a DFMC-only MOPS is required (i.e., using ABAS for integrity rather than SBAS or GBAS) and if an Integrity Support Message (ISM) default is needed for ARAIM.
- Matt Harris presented a status update on the GPS Velocity Working Group.
 - Membership from SC-159 and SC-186 (ADS-B)
 - SC-159 participants reviewed and concurred with a SC-186 Gauss-Markov model for GPS errors.
 - The Velocity Working Group would like SC-159 to concur that: “Velocity outputs based on GPS (and not SBAS) L1 carrier phase accumulated delta range measurements and velocity FOM can be tested to perform at levels commensurate with ADS-B NACv = 3 using existing RTCA MOPS / AC 20-138 velocity tests for NACv = 2 with success criteria based on NACv = 3 limits given the limitations assumptions described in this document”

- Barbara Clark provided a status update on an ad-hoc investigating a GNSS output to ADS-B to alert on jamming.
 - The ad hoc has been on hiatus but will be reactivated.
 - Eurocontrol has made progress on a concept of operations, which will be an input to the group.
- Denis Bouvet provided a summary of updates to EUROCAE's DFMC MOPS, ED-259, since the last SC-159 meeting in March.
 - During this time period, two EUROCAE WG-62 meetings have been held in May (Meeting #48) and September (Meeting #49).
 - Draft ED-259A v0.1 includes changes from Meeting #48 and v0.2 includes changes from Meeting #49. v0.2 was shared with SC-159 and the changes therein discussed.
- Laurent Azoulai provided a status update on the SC-159/WG-62 DFMC SBAS Authors Group
 - This group was initiated after the March 2019 SC-159 meeting.
 - DFMC progress has been made through discussion by the Authors Group with regard to:
 - DO-229 requirements tagging
 - Time to alert
 - Minimum tracking capability
 - MT0 processing
 - Spoofing
 - SBAS authentication
 - Data effective range
- Gary McGraw provided a presentation on alternative dual-frequency smoothing architectures for consideration by the group.
- Presentations were provided or discussions led on several ARAIM topics:
 - Laurent Azoulai led the discussion on 4 ARAIM questions: (1) Is ARAIM mandatory for a TSO?, (2) Are alternative algorithms ok?, (3) Is there a need for ISM default values?, and (4) Should equations be prescribed, or as for legacy RAIM should the MOPS just provide performance requirements and leave it to the avionics vendors to implement?
 - Todd Walter provided a presentation on ARAIM MOPS development.
 - Jason Burns provided an update on L5 CNAV ISM development. The Aerospace Corporation has proposed an ISM format and concept. These were briefed at a recent GPS Public Interface Control Working Group (PICWG). There are some open issues, which were discussed.
 - Mikael Mabillean provided a presentation with inputs on the addition of ARAIM to the DFMC MOPS.
- Laurent Azoulai provided a presentation with a preliminary proposal from Airbus on how spoofing mitigation should be addressed in the DFMC MOPS.
- Mikael Mabillean provided a presentation on issues and potential solutions for operations after the introduction of DFMC SBAS approaches in addition to current SBAS L1-only approaches.
- WG-2 requested to meet jointly with WG-4 for 3 days (M/T/W) during the March 2020 SC-159 week.

Agenda Item 4b. Review GPS/GLONASS Working Group (WG 2A) Progress and Identify Issues for Resolution.

Ms. Lada Semina of NNC Consulting LLC in Russia provided a presentation entitled “WG-2A GPS/GLONASS (NEW)”:

- The Russian Federation Ministry of Transport issued Order No. 183 on June 14, 2019.
 - This order requires that foreign-made aircraft imported into the Russian Federation after January 1, 2026, with a maximum take-off mass of more than 6,500 kg, are equipped with satellite navigation equipment capable of receiving and processing signals from the GLONASS.
- A new “MOPS for GLONASS / GPS multi-frequency satellite navigation equipment” has been drafted in Russia and posted to SC-159’s WG-2A workspace.
- Ms. Semina proposed that WG-2A be reactivated to develop a new GPS/GLONASS L1/L3/L5 MOPS using the draft document mentioned above as an input. She and Mr. Andrei Galyamov (NNC Consulting LLC) volunteered to serve as WG-2A co-chairs for this effort.

This proposal was discussed by the Plenary. It was noted that the addition of new products to a Special Committee’s work plan requires RTCA PMC approval, and that this also historically within RTCA has required a commitment to participate by at least two North American equipment vendors. A decision on whether SC-159 should propose a Terms of Reference update that includes the proposed new GPS/GLONASS product was deferred until March 2020. This decision postponement will allow SC-159 equipment manufacturer participants to consult with their companies as to whether they would be interested in supporting the proposed project.

The Plenary participants additionally had a number of questions regarding the future evolution plans for the GLONASS constellation. John Studenny volunteered to collect SC-159 questions on GLONASS to be provided to Ms. Semina and Mr. Galyamov. Questions should be provided to John by October 1, and he will collate the questions and provide them to Ms. Semina and Mr. Galyamov by November 1.

Barbara Clark noted that the Russian Federation has provided a lot of documents on GLONASS to the ICAO NSP. She offered to post these to SC-159’s Workspace.

Agenda Item 4c. Review GPS/Inertial Working Group (WG 2C) Progress and Identify Issues for Resolution.

Mats Brenner, chairman of WG 2C, presented the current status of that group.

- The working group is continuing to make good progress on the GNSS-aided Inertial System MOPS. WG-2C met for 2.5 days this week and additionally held 6 telecons since March. The draft MOPS is now 196 pages in length.
- This week’s meeting was focused on reviewing the MOPS draft for hidden/dormant issues so that they could be addressed in face-to-face discussions.

- Good progress was made in the telecons since March and additionally during SC-159 week on:
 - Appendix Q on alternate trajectories
 - Appendix M on off-line simulation methods
 - Appendix I on scintillation testing
 - Appendix L material on short-baseline heading determination
 - Pressure altitude bias modeling
 - Test for other parameters (e.g. pitch, ground speed) updated to align to updated satellite fault position based detection/exclusion test methods
 - Updates to make FDE requirements consistent with ARAIM
 - Appendix H on receiver interfaces
 - Gravity modeling
- The scintillation modelling material within the MOPS may be of interest for other SC-159 documents. A reference was provided to: Jayawardena et al., "Experimentally Recorded Amplitude and Phase Scintillation Through a Spirent Simulator," ION GNSS+ 2014: https://www.researchgate.net/publication/273142169_Experimentally_Recorded_Amplitude_and_Phase_Scintillation_through_a_Spirent_Simulator#pf6.
 - Some material has been removed from the draft MOPS based upon the updated RTCA proprietary information guidelines.
 - WG-2A anticipates completing the MOPS by mid-2020. Telecons between face-to-face meetings will continue towards this end.
 - WG-2C requested 2.5 days for the March 2020 SC-159 meeting (T/W/Th)

Agenda Item 4d. Review GPS/Precision Landing Guidance (WG 4) Progress and Identify Issues for Resolution.

Joel Wichgers and Matt Harris, chairmen of WG-4, proceeded to provide a summary of the working group 4 activities throughout the week.

- Working group 4 spent much of the week in joint meetings with working group 2. See summary above for Agenda Item 4a.
- The following items were discussed for the Thursday (October 3) WG-4 only meeting
 - Barbara Clark led discussion on an apparent discrepancy between the RTCA MOPS and ICAO SARPS on VDB undesired co-channel interference requirements. The conclusion of the discussion was that there is no discrepancy; the MOPS and SARPs requirements are equivalent, but use a different reference point (field strength vs receiver input) resulting in different numerical values.
 - Joel Wichgers presented information on possible concepts for Advanced-VDB (A-VDB) for GBAS and Advanced VHF Data Link (A-VDL) for communications. The group appreciated the information but expressed a preference for VDB alternatives that didn't change the waveform or protocol at this time.
 - Barbara Clark provided a brief description of Appendix O of the EUROCAE WG-28 ground GBAS MOPS. WG-28 has requested that WG-4 review.
 - Andreas Lipp led a presentation/discussion of the Conceptual Framework of DFMC GBAS. WG-4 members discussed and provided verbal feedback.

- WG-4 next discussed the status of the ICAO GBAS Working Group and the IGM Working Group. The VDB Ad Hoc group will continue to provide support for VHF compatibility guidance material. The SC-159 TOR date for a DFMC MOPS for which a TSO can be based needs to be aligned with the ICAO DFMC GBAS SARPs timeline.
- The EUROCAE WG-28 status was discussed. WG-28 has a working update of their GBAS Ground MOPS (ED-114). WG-4 will provide feedback. The next WG-28 meeting will be at the end of January. WG-28 will revisit the draft after the appendices are complete prior to beginning Open Consultation.
- Daniel Domey noted clarity issues with figure K-8 and the text describing this figure within Appendix K of DO-253D, Change 1. WG-4 has drafted errata to address these issues and requested SC-159 Plenary approval to proceed with the necessary steps to get the errata published by RTCA. The Plenary agreed to include a DO-253D Change 1 update within the next ToR update for presentation to the RTCA PMC.
- Andreas Lipp reported on GBAS inputs for the ICAO All Weather Operations Panel Manual. Some concern was expressed about the complexity of the system designations, and mapping that to the ability for flight planning to know if operational capability was being supported. Andreas is planning to provide a more simplified GBAS description for the Manual.
- WG-4 plans to hold telecons as needed prior to the next (March 2020) SC-159 week. One telecon has already been established for Dec 5. WG-4 requested to meet jointly with WG-2 for 3 days plus 1 day just for WG-4 at the March 2020 meeting.

Agenda Item 4e. Review GPS/Interference (WG 6) Progress and Identify Issues for Resolution

Sai Kalyanaraman, WG-6 Chair, discussed the Working Group efforts during the week.

- Discussions related to DO-235C (L1 Interference Report):
 - WG-6 continues to make progress on a C/N_0 link budget for the GPS L1 C/A-code
 - Zeta Associates has developed a “Critical SV” tool that computes C/A-to-C/A code interference using a model developed by MITRE for low-elevation angle critical GPS satellites using criteria that Zeta developed worked in conjunction with Stanford University. Results were provided that are being used in WG-6’s latest GPS L1 C/A-code link budgets.
 - Bob Erlandson has developed updated GPS L1 C/A-code link budgets for several operational scenarios.
 - The above material will be cross-checked and writing assignments have been made towards completing a complete draft of DO-235C. WG-6 hopes to complete FRAC by the March 2020 SC-159 meeting.
- Discussions related to DO-292A (L5 Interference Report):
 - ENAC provided significant inputs towards DO-292A, on topics including: (a) an improved (relative to DO-292) model for the impacts of pulsed interference including blanker effects on C/N_0 , (b) results using the new model for DME/TACAN and JTIDS/MIDS, (c) updated inter-/intra-system interference

results, and (d) an in-band L5 interference mask as a function of interference bandwidth.

- WG-6 hopes to enter FRAC for DO-292A prior to the October 2020 meeting and seek SC-159 approval of DO-292A at its October 2020 Plenary.
- WG-6 is getting closer to finalizing an interference mask vs frequency for DFMC equipment (that spans L1-to-L5 and beyond), which will also be needed for both DO-235C and DO-292A.

Agenda Item 4f. Review GPS/Antennas (WG 7) Progress

Sai Kalyanaraman, WG-7 Chair, discussed the Working Group efforts during the week.

- WG-7 released the DFMC antenna MOPS, DO-373, last year. No antenna is known to have been designed to comply with this MOPS. WG-7 continues to discuss new material on DFMC antennas and will consider whether any changes to DO-373 are necessary.
- Stefan Caizzone of DLR provided an update on DUFMAN-related antenna activities. It has been observed that different antennas provide different performance with respect to multipath when installed in the same position on the same aircraft. It was suggested that a Multipath Suppression Indicator (MPSI) may be useful to distinguish between antennas and DLR has proposed a MPSI metric. Data was provided to justify the metric and Stefan welcomed feedback on their findings.
- WG-7 discussed the DLR presentation and also whether additional equipment classes or new requirements should be considered for the DFMC Antenna MOPS. No decisions were made, and these discussions will continue.

Agenda Item 5. Review of EUROCAE Activities and Discussion of Joint Activity with EUROCAE on a Dual-Frequency, Multi-Constellation GNSS Receiver MOPS

Pierre Durel provided an update on EUROCAE WG-62:

- Two meetings were held since the last SC-159 plenary in March:
 - 48th meeting was held at Eurocontrol May 13 – 17
 - 49th meeting was held at ENAC September 9 - 13
- The group continues to discuss numerous topics related to updating ED-259
- The next meetings of WG 62 are:
 - 16-20 December 2019 (ENAC, Toulouse) 50th Meeting.
 - 11-15 May 2020 (EASA, Köln) 51st Meeting.
 - TBD December 2020 (EUROCAE, Paris) 52nd Meeting.

Agenda Item 6. Update on ICAO/Navigation Systems Panel

ICAO NSP was discussed during the WG-2/4 meeting review as summarized in Agenda Item 4a above and no further discussion was necessary.

Agenda Item 7. Discussion of Terms of Reference Updates

Chris Hegarty led the committee in a discussion regarding changes to the SC-159 Terms of Reference. The objective for this ToR update is to formalize the plan for WG-2 to work jointly

with WG-62 on the DFMC SBAS MOPS. WG-2 provided a draft ToR update, which was used as a starting point for the discussion. The Plenary approved a markup that included:

- Text revisions to the Background section, including significantly the statement that SC-159 is only considering GNSS signals centered at 1575.42 MHz and 1176.45 MHz with usable bandwidths of no more than +/-12 MHz. And that “other conditions” may apply such as the signal being open and being supported by the service provider for safety-of-life use.
- Deletion of the already-published DO-253D Change 1.
- Delay of the WG-6 products (DO-235C from October 2019 to March 2020 and DO-292A from March 2020 to October 2020).
- Revisions to the description of the first and second versions of the GNSS(SBAS) L1/L5 MOPS. The description of the first version was changed to “GPS/Galileo/SBAS MOPS jointly with EUROCAE WG-62 intended to be usable for ETSO/TSO production and certification of the receivers for aviation use”. The second version was changed to “Update to GPS/Galileo/SBAS MOPS for dual-frequency equipment”. “December” was added to the years that were on the previous version of the ToR (2020 for the first MOPS, 2022 for the second MOPS). A number of footnotes were added with objectives for operations to be enabled by the two DFMC SBAS MOPS versions.
- In Specific Guidance a previous note that the SBAS DFMC MOPS “should” be jointly developed with WG-62 was changed to “will”.
- In “Initial Documentation”, EUROCAE ED-259 and the US-EU WG-C ARAIM Airborne ADD were added in addition to updates to the RTCA document numbers.

Chris and George will provide the proposed ToR update to the PMC for consideration at their December 2019 meeting.

Agenda Items 8 and 9. Action Item Review and Assignment/Review of Future Work

The Plenary reviewed actions that were agreed to in the meeting. These included:

1. All SC-159 participants – provide any questions you may have on the evolution of the GLONASS constellation to John Studenny by October 31. John will collate and provide to Lada and Alexei on Nov 1 (see discussion under Agenda Item 4b above).
2. Barbara Clark will post relevant ICAO NSP GLONASS papers to Workspace (see discussion under Agenda Item 4b above).
3. SC-159 equipment manufacturer participants – discuss with your company’s leadership whether you might commit to supporting the development of a new GPS/GLONASS L1/L3/L5 MOPS as proposed by Lada and Alexei (see discussion under Agenda Item 4b above).
4. WG-2 and WG-2C leadership to establish a telecon to coordinate on topics of mutual interest. These topics include tests for spoofing and how to integrate requirements for false alarm rate with the RAIM step detector.

Agenda Item 10. Other Business

There were no “Other Business” items raised.

Agenda Item 11. Date and Place of Next Meeting

The 105th meeting will take place the week of March 9th – March 13th, 2020. The WG schedule will be finalized at a later time. The 106th meeting will take place the week of October 19th – 23rd, 2020.

Chris Hegarty adjourned the meeting.

CERTIFIED as a true and accurate summary of the meeting.

-S-
Christopher Hegarty
Co-chairman

-S-
George Ligler
Co-chairman