



Summary of the Ninety-Fifth Meeting

Special Committee 159

**Minimum Operational Performance Standards for Airborne Navigation
Equipment Using the Global Positioning System (GPS)**

The ninety-fifth Plenary meeting of SC-159 was held March 11th, 2016 at RTCA Headquarters, 1150 18th Street NW, Suite 910, Washington, D.C. 20036. The attendees were the following:

Christopher Hegarty (Co-Chairman)	The MITRE Corporation
George Ligler (Co-Chairman)	PMEI
Kyle Wesson (Secretary)	ZETA Associates
Ken Alexander (DFO)	Federal Aviation Administration
NAME	COMPANY
Adams, Hal	Accord Software & Systems, Inc.
Anand, Shiva	The MITRE Corporation
Ashton, Ken	Nu-Approach Ltd
Azoulai, Laurent	Airbus
Biggs, Michael	Federal Aviation Administration
Blanco, Nuria	European Satellite Services Provider (ESSP) – SAS
Brenner, Mats	Honeywell International, Inc
Bridges, Kevin	Federal Aviation Administration
Clark, Barbara	Federal Aviation Administration
Domey, Daniel	Esterline CMC Electronics
Ennenga, Ben	R.A. Miller Industries, Inc. DBA RAMI
Foley, John	Garmin Ltd.
Harris, Matt	The Boeing Company
Hiliuta, Adrian	Esterline CMC Electronics
Iatsouk, Victor	Russian Federal Space Agency
Irwin, Barry	The MITRE Corporation
Kalyanaraman, Sai	Rockwell Collins, Inc.
O'Laughlin, Dan	The MITRE Corporation
Owen, John	Defence Science Technology Laboratory (DSTL)
Snowball, Allen	Defence Science Technology Laboratory (DSTL)
Stearn, Geoff	Ligado Networks
Studenny, John	Esterline CMC Electronics
Trautenberg, Dr. Hans	EASA
Walton, Rick	Lockheed Martin Corporation
Wichgers, Joel	Rockwell Collins, Inc

The agenda for the meeting follows:

1. Chairman's Introductory Remarks.
2. Approval of Summary of the Ninety-Fourth Meeting held October 23, 2015, RTCA Paper No. 041-16/SC159-1047.
3. 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)
4. Review of EUROCAE Activities.
5. Action Item Review
 - a. Coordination of SC-159 TOR dates and DFMC MOPS efforts with other standards bodies
 - b. DME Interference to GNSS signals in the future
 - c. Updating SC-159 Document Schedules in the SC-159 TOR
6. Assignment/Review of Future Work.
7. Other Business.
8. Date and Place of Next Meeting.
9. Adjourn

In accordance with the Federal Aviation Advisory Committee Act, Ken Alexander, Federal Aviation Administration (FAA), was the designated Federal Employee for this meeting.

Agenda Item 1. Chairman's Introductory Remarks.

- At the suggestion of Co-Chairman George Ligler, attendees introduced themselves.
- Jennifer Iverson, Program Director of RTCA, discussed RTCA's membership policy and proprietary references policy.

Agenda Item 2. Approval of Summary of the Ninety-Fourth Meeting held October 23, 2015, RTCA Paper No. 041-16/SC159-1047.

- The summary was approved without change.

Agenda Item 3. Review Working Group (WG) Progress and Identify Issues for Resolution.

a. GPS/3rd Civil Frequency (WG-1)

- WG-1 was disbanded in October 2012, and there is no activity to report.

b. GPS/WAAS (WG-2) (Co-chairs: John Studenny and Laurent Azoulai)

- Laurent and John provided a summary of WG-2 at the Plenary. The working group covered the following topics, with paper numbers corresponding to the agenda item. For further details, please download the WG-2 presentation to the Plenary from the RTCA workspace.
 - 2.a - WAAS update
 - 3.a - EGNOS Performance and LPV Implementation Status
 - 5.a Galileo status

- 6.a SBAS PRN List Expansion
- 6.b PRNs allowed for SBAS GEOs
- 6.c SBAS PRN proposed MOPS changes
- 6.d Proposed approach to address SBAS PRN List expansion
- 7.a Prevention of using cross-correlated PRNs
- 7.b Navigation Message Correction Table
- 7.c (De)-Selection of SBAS providers
- 12.a ICAO NSP DF/MC CONOPS
- 12.b DFMC standardization activities in the frame of ATLAS project
- 12.c DFMC SBAS Definition Document Status
- 12.d Status of the DFMC ICD
- 12.e Assumptions on the DFMC SBAS MOPS
- 12.f GPS IODE/IODC Anomalous Re-Use
- 12.g ARAIM Milestone III report
- 12.h GPS/Glonass RAIM
- Regarding the WG-2 recommendation on developing DO-229E to specify receiver requirements for expansion in the number of PRN codes for SBAS geostationary satellites (items 6.a – 6.d):
 - The Plenary decided that the FRAC for DO-229E would start on September 1st, 2016.
 - **ACTION:** Jennifer Iverson will add this agenda item to the Federal Register Notice for the SC-159 Plenary’s October 21st, 2016 meeting.
 - **ACTION:** To support the PRN expansion and DO-229E, WG-6 will get updates on Ignss, taking into consideration CA on CA and SBAS aggregate gain factor (Gagg).
- Regarding the issue of de-selection of SBAS providers (item 7.c):
 - **ACTION:** WG-2 will form a subgroup to work the issue and will inform the Plenary by end of June on the necessity of including this content in DO-229E.
- The next WG-2 meeting will take place over two days the week of the next SC-159 meeting (week of October 17th, 2016). Please refer to Agenda Item 8 for the proposed scheduling.

c. GPS/GLONASS (WG-2A) (Chair: Victor Iatsouk)

- Victor provided a summary of WG-2A at the Plenary. For further details, please download the WG-2A presentation to the Plenary from the RTCA workspace. The working group covered the following topics:
 - Concerns over adequacy of current RAIM for GPS/GLONASS /ABAS MOPS and related issues:
 - intended applications (RNP 0.3, optional ADS-B)
 - current GPS-GLONASS accuracy levels
 - constellation failures (Pconst)
 - satellite failure rates (P_{sat})
 - P_{sat} discussion
 - Note to definition of FDE (Section 1.7.3 in draft MOPS): *The probability of a GPS or GLONASS satellite integrity failure being included in the position solution used in RAIM is less than or equal to 10⁻⁴ per hour (see definition of HAL above). Legacy [GPS] RAIM is based upon ten satellites in view, each with a P_{sat} of 10⁻⁵. Values for the algorithm need to account for the increased number of satellites if a combined solution is used. Additionally, the RAIM algorithm needs to be adjusted if P_{sat} of 10⁻⁵ is not substantiated.*
 - Interference criteria - no support for proposed optimized integrated mask in this GPS/GLONASS MOPS
 - Combined antenna specs – passive & active designs considered; active option is specified
 - Proposed antenna specs referred to WG-7 for preliminary general assessment and report to Plenary

- Antenna manufacturers of GPS-GLONASS antennas responded that the frequency selectivity mask proposed by Ligado (previously LightSquared) in the RTCA WG-2A meeting of October 20, 2015 was not difficult to achieve. Ligado stated, however, that in the interest of getting the MOPS completed by the target date, it has chosen not to press for a mask change in WG-2A, but will focus its efforts on the mask to be developed in WG-7. Ligado said that it believes this information will be useful in developing a mask that maximizes frequency selectivity while meeting all the other performance requirements established by WG-7.
- **ACTION:** The Plenary agreed to initiate a GPS/GLONASS/ABAS L1 MOPS 45-day FRAC starting in June/July. WG-7 will provide, within two weeks, WG-2A feedback on the antenna mask if there are any major concerns. Then WG-2A will post the GPS/GLONASS/ABAS L1 MOPS for FRAC.
- **ACTION:** Jennifer Iverson will add this agenda item to the Federal Register Notice for SC-159's October 21st, 2016 Plenary meeting.
- **ACTION:** WG-2A to update the GNSS table for the FDMA GLONASS constellation.
- The next WG-2A meeting will take place over two days the week of the next SC-159 meeting (week of October 17th). If necessary, a meeting on Friday, October 14th, 2016 may be called. Please refer to Agenda Item 8 for the proposed scheduling.

d. GPS/Inertial (WG-2C) (Co-chairs: Kevin Bridges and Mats Brenner)

- Mats provided a summary of WG-2C at the Plenary. For further details, please download the WG-2C presentation to the Plenary from the RTCA workspace.
- WG2C is working on a MOPS for GNSS aided inertial systems (including AHRS grade sensors). Discussion and presentations included:
 - JAXA presentation on ionosphere bubble impact
 - JAXA update on heading estimation based on aircraft motion
 - Presentation on GPS fault modes affecting pseudo range and delta range (Rockwell Collins)
 - Presentation on receiver requirements needed for dual antenna heading determination
 - Lengthy discussions regarding L1 lambda ambiguity and integrity of heading
 - GNSS based heading is optional and the plan is to put recommendations on requirements and test methods in an appendix
 - Completion of section 1 walk-through
 - Section 2 draft walk-through: Requirements section from appendix R had been updated to address the new scope and associated issues (category A,B and C and sub category 0,1,2).
 - Request to change “false alert rate” to “false detection rate” since that is what being tested
 - Potential conflict between GNSS aiding allowed by DO-334 and new MOPS resolved
 - Group discussed necessity of specifying time to alert for other (non-position) parameters
 - Established that MOPS requirements only apply to parameters that are affected by SIS performance
 - Some discussion circled around the use of a 99.9% uncertainty limit such as HUL
 - SBAS aiding discussed: Integration with SBAS would require different error models and fault modes and is out of scope
 - Group wrestled with formulation of key integration requirement: Claimed performance over and above basic FDE (typically occurring in RAIM holes)
 - Review continued with non GNSS aiding requirements (clock, barometric altitude , magnetometer and dual antenna based heading)
 - Ionospheric storm test data currently in custody at Stanford. FAA action (Kevin) to see if it can be moved to RTCA-owned drive (e.g. Workspace)

- Issue raised regarding other types of fault modes that could affect velocity, attitude or heading
- Result from receiver interface subgroup
- Group further discussed output latency for parameters such as (hybrid) pitch and heading
- Presentation on test trajectories (Garmin)
- Alternative method to address this was suggested (Rockwell Collins)
- The next WG-2C meeting will take place over two and a half days the week of the next SC-159 meeting. Intermediate telecons will also occur. Please refer to Agenda Item 8 for the proposed scheduling.

e. GPS/Precision Landing Guidance (WG-4) (Co-chairs: Joel Wichgers and Matt Harris)

- Joel provided a summary of WG-4 at the Plenary. For further details, please download the WG-4 presentation to the Plenary from the RTCA workspace.
- Near Term Work Products
 - Revise RTCA GPS/LAAS Airborne MOPS (DO-253 rev. C to D)
 - Revise RTCA GPS/LAAS Interface Control Doc. (ICD) (DO-246 rev. D to E)
- Near Term work schedule is tied to ICAO NSP. Plan to FRAC after ICAO NSP has completed Validation on the ICAO SARPs
- ICAO NSP is planning to complete validation for the GBAS SARPs amendment that includes GAST D Service in December 2016
- Contingent on ICAO NSP completing validation, plan to FRAC in January 2017 and Seek SC-159 Plenary Approval of DO-253D & DO-246E in March 2017.
- A number of issues are taking longer to close, examples:
 - ICAO GBAS SARPs validation of Iono. Threat Monitoring.
 - Extended Service Volume (ESV) [May get deferred]
- A number of issues are emerging:
 - VDB Compatibility Being Reassessed with ILS, VOR, and VHF Comm. Systems, may result in Adjacent Channel Interference Rqmts.
 - Antenna Group Delay Variations with Angle of Arrival Possibly Larger than antenna MOPS
 - Request for VDB Tx Antenna Diversity in Same Time Slot
 - Open Issues with regard to the Authentication Protocol: SSID Issue with MT2, Antenna Diversity
- Longer Term Work Products
 - Revise RTCA GPS/LAAS Airborne MOPS Requirements
 - Revise RTCA GPS/LAAS Interface Control Doc. (ICD) Requirements
- The next WG-4 meeting will take place over three days the week of the next SC-159 meeting. Intermediate telecons will also occur. Please refer to Agenda Item 8 for the proposed scheduling.

f. GPS/Airport Surface Surveillance (WG-5)

- There has been no activity since the last meeting.

g. GPS/Interference (WG-6) (Chair: Sai Kalyanaraman)

- Sai provided a summary of WG-6 at the Plenary. For further details, please download the WG-6 presentation to the Plenary from the RTCA workspace. The agenda covered:
 - Galileo and SBAS Link Budget
 - C/A on C/A interference discussion
 - SBAS Gagg discussion
 - Assessment of OOB from other wireless Base Stations
 - Updates to DO-235B and DO-292

- **ACTION [copied from above]:** To support the PRN expansion and DO-229 revision, WG-6 will get updates on Ignss, taking into consideration CA on CA and SBAS Gagg.
- **ACTION:** WG-6 is to include a recommendation on a new mask in the December 2017 report.
- The next WG-6 meeting will take place over a half day the week of the next SC-159 meeting. Please refer to Agenda Item 8 for the proposed scheduling.

h. GPS/Antennas (WG-7) (Co-chairs: A. J. Van Dierendonck and Sai Kalyanaraman)

- Sai provided a summary of WG-7 at the Plenary. For further details, please download the WG-7 presentation to the Plenary from the RTCA workspace. The agenda covered:
 - Ligado, RAMI and PCTEL presented potential antenna design for a more frequency selective design at L1
 - Reviewed antenna group delay bias presentation (from Matt Harris)
 - WG-2A requested that WG7 review updated antenna material in the GPS-Glonass MOPS
 - Discussions on MCMF (L1/L5/E1b,c/E5a) antenna:
 - G/T discussions for L1/E1
 - Noise Figure at L5
 - Antenna gain slope variations (gain vs elevation)
 - Group delay vs Azimuth
- **ACTION [copied from above]:** The Plenary agreed to initiate a GPS/GLONASS/ABAS L1 MOPS 45-day FRAC starting in June/July. WG-7 will provide, within two weeks, WG-2A feedback on the antenna mask if there are any major concerns. Then WG-2A will post the GPS/GLONASS/ABAS L1 MOPS for FRAC.
- The next WG-7 meeting will take place over a half day the week of the next SC-159 meeting. Please refer to Agenda Item 8 for the proposed scheduling.

Agenda Item 4. Review of EUROCAE Activities.

- Laurent Azoulai gave updates on EUROCAE activities (EUROCAE WG-28 and WG-62-39).
- Please access the presentations on the RTCA workspace for further details.
- The SC-159 Co-Chairs took an action to discuss with the PMC, in response to requests from EUROCAE, making one or more deliverables related to the DFMC MOPS joint documents between RTCA and EUROCAE. The meeting discussed the need for the schedule and scope of any joint document to be agreed between RTCA and EUROCAE before inception of such a joint effort.

Agenda Item 5. Action Item Review

a. Coordination of SC-159 TOR dates and DFMC MOPS efforts with other standards bodies

- Action is to be subsumed into more systematic discussion of the dates that was assigned to the Plenary
- Status: Closed, see Agenda Item 6.

b. DME Interference to GNSS signals in the future

- FAA is currently determining deployment, relocation, and signal strength
- Navigation Programs will coordinate with Spectrum to provide a briefing to RTCA at the October 21st, 2016 Plenary.
- Status: Open

c. Updating SC-159 TOR

- DO-229E is a new product and there are a slight change to the dates for some existing products in the SC-159 TOR..
- **ACTION:** Jennifer to submit to document PMC with paper number holder from Karan Hofmann.
- Status: Closed

Agenda Item 6. Assignment/Review of Future Work.

- **Plenary Action for the Chairs:** draft formal communication to SBAS providers and other standards bodies informing them of SC-159 work products and efforts.

Agenda Item 7. Other Business.

- There was a question about joint WG-4 and ICAO meetings. The consensus was that joint meetings are not a concern and they are in accordance with the RTCA membership policy.

Agenda Item 8. Date and Place of Next Meeting

The 96th meeting of RTCA SC-159 will be during the week of October 17th, 2016 at RTCA Headquarters. The proposed meeting schedule is as follows:

	October 17 (Monday)	October 18 (Tuesday)	October 19 (Wednesday)	October 20 (Thursday)	October 21 (Friday)
WG-1 (3 rd civil frequency)					
WG-2 (GPS/WAAS)	1 st day @ 9:00 a.m.	2 nd day @ 9:00 a.m.			
WG-2A (GPS/GLONASS)			1 st day (half) @ 9:00 a.m.	2 nd day (half) @ 9:00 a.m.	
WG-2C (GPS/Inertial)		1 st day @ 9:00 a.m.	2 nd day @ 9:00 a.m.	3 rd day (half) @ 9:00 am	
WG-4 (GPS/Precision Landing)		1 st day @ 9:00 a.m.	2 nd day @ 9:00 a.m.	3 rd day @ 9:00 a.m.	
WG-5 (Airport Surface Operations)					
WG-6 (Interference)				Half day @ 1:00 p.m.	
WG-7 (Antenna)				Half day @ 9:00 a.m.	
Plenary Session					One day @ 9:00 a.m.

The 97th meeting will be held during the week of March 13th, 2017.

-S-
Kyle Wesson
Secretary

CERTIFIED as a true and accurate summary of the meeting

-S-
Christopher Hegarty
Co-chairman

-S-
George Ligler
Co-chairman