

Summary of the One Hundred and Third Meeting

Special Committee 159

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

The one hundred and third meeting of SC-159 was held March 8, 2019 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)	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)
Shiva Anand	The MITRE Corporation
Laurent Azoulai	Airbus
Denis Bouvet	Thales Group
Mats Brenner	Honeywell International, Inc.
Jason Burns	Federal Aviation Administration (FAA)
Stefano Caizzone	German Aerospace Center DLR
Forrest Colliver	AviaGlobal Group
Pierre Durel	European GNSS Agency
Michael Felux	German Aerospace Center DLR
James Fernow	The MITRE Corporation
John Foley	Garmin Ltd.
Andrey Galyamov	NNC Consulting LLC
Axel Garosa-Pena	EMAC
Thomas Googe	American Airlines, Inc.
Matt Harris	The Boeing Company
Tetsuya JO	Civil Aviation Bureau of Japan
Sai Kalyanaraman	Rockwell Collins, Inc.
Vladimir Latev	Universal Avionics Systems Corp.
Yutaka Marukawa	Japan Radio Air Navigation Systems Association
Shinichi OCHIAI	Japan Radio Air Navigation Systems Association
Charles Phifer	Federal Aviation Administration (FAA)
Carlos Rodriguez	Federal Aviation Administration (FAA)
Jaron Samson	European Space Agency

Khambrel Simpson
Dale Swanson
Hans Trautenberg
Hidetsugu WADA
Joel Wichgers

The MITRE Corporation
The MITRE Corporation
European Aviation Safety Agency (EASA)
Civil Aviation Bureau of Japan
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 Second Meeting held October 5, 2018 (RTCA Paper No. 037-19/SC159-1077)
3. Final Review and Comment (FRAC) activities
 - a. DO-235C (WG-6) Release for FRAC
 - b. DO-246E Change 1 (WG-4) FRAC Resolution
 - c. DO-253D Change 1 (WG-4) FRAC Resolution
 - d. 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.

Note that, with the agreement of the chairmen and other participants, the agenda was reordered to accommodate the availability of certain participants. The order in the minutes below reflects the actual sequence of topics.

Agenda Item 1. Chairman’s Introductory Remarks.

- At the suggestion of Co-Chairman George Ligler, 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 US 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.
- All attendees were present in person.

Agenda Item 2. Approval of Summaries of Previous Meetings.

- a. The summary for the 102nd meeting, RTCA Paper No. 037-19/SC159-1077, were posted immediately prior to the meeting and as a result were not available for review. Participants were encouraged to review the minutes and provided comments to John Savoy or Karan Hofmann by March 22, 2019.

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 FRAC for DO-235 could not enter FRAC due to issues with intra-system C/A on C/A interference. He requested an extension with an intent to complete the FRAC period prior to the upcoming October meeting. The Plenary meeting approved this extension.

- d. DO-292A (WG-6) Release for FRAC
Mr. Kalyanaraman asked the committee to consider extending the deadline for beginning this process until after the October meeting.

- b. DO-246E Change 1 (WG-4) FRAC Resolution
Matt Harris, co-chairman of working group 4, indicated that only a single comment was made regarding the proposed DO-246E and that a plan for the resolution of that comment had been determined.

- c. DO-253D Change 1 (WG-4) FRAC Resolution
Mr. Harris noted that 43 comments were made regarding the proposed DO-253D were received and that a plan for the resolution of that comment had been determined. The

working group intends to provide feedback to the ICAO Navigation System Panel.

The plenary committee presented no further comments for either of the WG-4 documents and, following a motion by Joel Wichgers and Sai Kalyanaraman, voted unanimously to forward the finalized documents to the RTCA PMC for final approval.

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

Mr. Harris proceeded to provide a summary of the working group 4 activities throughout the week.

- Working group 4 discussed support for the update of ICAO DOC 8071, the Manual on Testing Radio Navigation Aids. The working group plans to provide guidance regarding how flight inspection procedures should deal with small numbers of inspection measurements that are outside of tolerance. The update to this document is planned to be complete by the end of 2019.
- Working group 4 spent much of the week in joint meetings with working group 2. That material to be presented later in this meeting.
- The working group reviewed a conceptual framework for the future dual-frequency/multi-constellation (DF/MC) GBAS MOPS developed as part of the SESAR effort. The proposed framework is lengthy and detailed and the cursory review only covered a few topics of particular interest.
 - The capacity of the current VDB channel may not be sufficient to support DF/MC corrections.
 - Is it more appropriate for the DF/MC GBAS airborne equipment to compute an ionosphere-free position or to use single-frequency measurements with ionospheric corruption left intact, but incorporating differential corrections to mitigate the ionospheric error and an dual frequency ionosphere monitor to determine if those corrections have become unusable.

The working group was asked to provide feedback regarding several topics including limitations of airborne equipment to perform multiple simultaneous solution, the need for an L5-only reversion mode, and the use of disparate ephemeris received on each of the tracked frequencies.

- Sam Pullen presented an evaluation of the differences between an iono-free and divergence-free measurement models, noting that divergence-free techniques result in higher availability but leave no ability to deal with ionospheric anomalies while iono-free techniques allow the equipment to provided functionality even when the ionospheric anomalies are present, but has a relatively low availability. A hybrid technique provides the best qualities of both methods but places a higher demand on receiver processing capacity. The plenary committee briefly discussed the fact that several patents may exist that would constrain the use of either or both techniques and that care should be taken to ensure the standard does not mandate the use of intellectual property.
- Tetsuya Jo provided status of the use of GBAS in Japan.
 - NEC is planning to begin operational use of a GAST C GBAS station at the Haneda airport in March of 2021. This ground station uses two distinct VDB transmitters as well as two ionospheric far-field monitors.
 - The Civil Aviation Bureau is currently studying the benefits of using GLS and LPV at other airports currently served by ILS.

- Stefano Caizzone described work in which it is shown that different antenna designs perform better when exposed to multipath. He presented a method for identifying antenna that perform better using data collected during measurement of group delay variation. The working group did not find the notion of specifying this particular antenna performance to be particularly desirable but did acknowledge that this may provide an additional degree of freedom if we find that some DF/MC operations do not have sufficient availability.
- The group plans to have additional teleconferences and meetings to continue periodic coordination with the ICAO NSP for the update of ICAO DOC 8071.

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

Laurent Azoulai, co-chairman for working group 2, discussed the progress made by that group during the week.

- Working groups 2 and 4 met throughout the week to make common progress on the new dual frequency, multi-constellation MOPS.
- Jason Burns informed the joint working group on the current status of the WAAS program.
 - WAAS coverage for LPV and LPV-200 service remains excellent.
 - Mr. Burns indicated that the WAAS program is planning for dual-frequency WAAS operations. There is a push to put the framework for implementation of Horizontal, Advanced Receiver Autonomous Integrity Monitoring, H-ARAIM.
 - The Phase IV Segment A activities will complete in September of 2021 with 7 releases. The 5th release is currently under way.
 - The WAAS team will continue to operate a three-satellite GEO constellation with two satellites under development.
 - WAAS continues to meet its performance commitments
 - There are currently over 4,665 LP/LPV procedures published with over 118,000 WAAS equipped aircraft operating within the NAS.
- Pierre Durel briefed the working groups on the status of the EGNOS program.
 - Mr. Durel showed that there were currently four EGNOS satellites in operation with two serving as active backups. The Ground segment had been operating using system release 2.4.1N since February of 2019.
 - Mr. Durel informed on the extents of EGNOS coverage and noted that coverage improved significantly with the infrastructure changes described at the last meeting of SC-159.
 - As of February 2019, there were 342 airports and 498 runways served with EGNOS LPV procedures.
 - Mr. Durel described to the working group the EGNOS services roadmap, which showed the evolution of EGNOS to support dual-frequency, multi-constellation functionality. Mr. Azoulai described the EGNOS V3 DFMC transition plan. This plan indicated that DFMC SBAS operation could commence as early as 2025.
 - Mr. Azoulai showed the group a slide showing the work taking place in the EU to further the development of ARAIM. This slide was not discussed in detail.

- Hidetsugu Wada described for the working groups the current status of the MSAS program.
 - Mr. Wada showed the joint group an implementation plan which would provide for LPV operations in Japan in approximately 2023 as well as a dual-frequency, multi-constellation implementation phase, which began in 2017. This is very similar to slides presented to SC-159 in the past.
 - Mr. Azoulai showed the committee members a graphic with the 10-year plan for MSAS enhancement. Interested parties were referred to the presentation that would be posted on the working group workspace.
 - Mr. Wada informed the joint working group that the MSAS user base has been steadily increasing and noted that operators were very interested in having MSAS support LPV operations.
- Pierre Durel provided status on the work by DS2
 - The DS2 group was created specifically to create DFMC SARPS requirements.
 - A technical baseline has been created but is not yet approved. This baseline will be released by ICAO Electronic Bulletin in March 2019.
 - The group intends to proceed with validation and to have that effort completed by the end of 2020.
- Kevin Bean and Dale Swanson presented material describing analyses done on the ionospheric error bounds in DO0-229, Appendix J. In 2005, MITRE informed SC-159 that it was likely that the current ionospheric error model may not be sufficiently conservative in some case. In 2010, it was reported that the model may result in overly conservative estimates of horizontal figure of merit. In 2017 MITRE proposed a method that would reduce the HFOM and eliminate some of that conservatism. Working group 2 decided that it would be appropriate to keep the current ionospheric error model in DO-229E. The group further concluded that it may be worth reexamining this model for the new DFMC MOPS. It is not clear what, if any, operational needs would warrant this additional effort.
- Barbara Clark presented a plan to add requirement “tags” to each unique requirement of DO-229E in a manner similar to that of DO-253. This would allow for a more robust traceability between the legacy DO-229 requirements and the new requirements of the DFMC MOPS. There is some question as to whether this would constitute a revision of DO-229E.
- The working group considered the development of a new Concept of Operations Document that would describe new use cases for the DFMC receiver that cannot be addressed by the current single frequency equipment. These new use cases include functions such as LPV200 autoland, CAT II autoland, and LPV 200 in equatorial regions. The working group will form an author’s group to develop this document in the coming months.
- Matt Harris led a discussion covering observed vertical velocity errors. Previously, SC-186 and MITRE had described analysis performed on collected ADS-B Out reports that appears to indicate there may be vertical velocity errors which are not properly accounted for by airborne equipment. Further analysis was performed on flight test data taken from multiple aircraft performing multiple operations. The working group concluded from this analysis that there is no issue with the current implementations. That is, the actual receiver accuracy is quite good, properly reflects true aircraft motion and is properly bounded by the output velocity figures of merit.
- Denis Bouvet presented material describing EUROCAE WG-62’s efforts to develop the DFMC SBAS MOPS, ED-259. An initial version of this document was published in

February 2019. Several key elements of this document are not complete. Nevertheless, the document can be purchased from EUROCAE.

- The working group considered the implications of a need to rapidly change selected runways on the DFMC receiver's requirements for minimum number of tracking channels, minimum time for transition between two SBAS signals and the rapid selection of SBS data provider. The currently proposes DFMC requirements would lead to implementations that could take more than 2 minutes to switch between SBAS signals. This switch should take no more than 15 seconds to prevent operational difficulties. These requirements will clearly need to be revisited.
- The working group discussed time-to-alert requirements for the DFMC receiver that are derived from the ICAO SARPS but are not very clear. A small group will review the ICAO material and present a paper clarify the proper allocations.
- The working group considered developing a means to help airborne equipment to determine what SBAS satellites were available. This could potentially aid acquisition of new SBAS signals. While this would be useful, airborne equipment would still need to search for new signals in the event that the provided information was incomplete or out of date.
- Todd Walter presented a new algorithm to bound the errors of the smoothed pseudorange using the smoothing time and the final converged value. He also described work to validate that model using data collected in an airborne receiver. While this model appears to adequately account for the effects of smoothing for GPS and Galileo measurements, it is not sufficiently conservative during convergence.
- Jaron Samson asked receiver manufactures to assess the impact of lowering the update rate of SBAS fast corrections.
- Jason Burns led the working group in a discussion regarding the use of the GPS CNAV signal to carry an integrity status message. The FAA is working with Aerospace Corporation to study this concept with the goal of preparing an update of IS-GPS-705 to be presented to the PICWG in September of 2019.
- Matt Harris led the group in a discussion regarding the requirements for GNSS velocity accuracy.
 - The plenary committee discussed the fact that receiver manufacturers are now providing equipment that is capable of transmitting velocity figures of merit that support $NAC_v=3$ and 4. However, no standardized means of validating those equipment exist. This leads to very real certification issues.
 - The working group will define test procedures and means of compliance with a goal to have this ready by the end of May.
 - SC-186 has developed a horizontal velocity error model. SC-228 would like to develop a vertical velocity error model.
- Stefano Caizzone and Michael Felux presented a study being performed to assess how antenna design impacts multipath effects. The desire is to create a specification for antenna multipath.
- Barbara Clark asked the working group to perform a review of the GPS Standard Positioning Service specification, GPS Interface Control Document, ICAO SARPS and assumptions in the existing MOPS for inconsistencies. Formal comments should be provided to Ms. Clark by March 29th.

- The working group has been meeting with EUROCAE WG-62 to resolve several issues in preparation for the development of a joint DFMC MOPS.
 - The joint group made several assumptions regarding the scope of the MOPS. GPS L5 and Galileo SARPS, DO-235C and DP-292 A will be completed prior to 2020; SBAS authentication may be mandatory but there is not current SARPS baseline for these elements; and ARAIM will be included but it is not required for the completion of the initial joint MOPS.
 - Several MOPS components will be required for the initial MOPS. Clear and defined operational use cases; requirements for class Beta, and class Delta as well some requirements for class Gamma; integration of DO-229E; and DFMC SBAS are all mandatory. ARAIM integrity and certain navigator portions of the class Gamma requirements are optional.
 - Several MOPS components are defined as out of scope. These include L5 SBAS ranging, non-geosynchronous SBAS satellites, SBAS authentication and SBAS service area messages.
 - There are some risks that should be addressed. DO-235C and DO-292A may not be available prior to March 2020. Once these documents are complete, it may be necessary to make changes to the currently released antenna MOPS.
 - SC-159 and WG-62 are planning to work as a single group authoring a single document. The intent is to make an update to the existing terms of reference for SC-159 and WG-62 to make the responsibilities of each group clear.
 - The plenary committee approved the development approach presented by Mr. Azoulai and wishes to express gratitude to the working group members that put this plan together.
- Barbara Clark and Hans Trautenberg led a discussion regarding GPS interference and spoofing. Both the FAA and EASA, as well as the ICAO NSP have expressed a need for any future MOPS work to include a best effort for addressing interference and spoofing. However, what is entailed by “best effort” is not entirely clear. The working group is currently planning on developing a “restricted access” MOPS addendum to capture interference and spoofing requirements and test procedures.
- A proposal was made at the September 2018 GPS Interface Control Working Group to remove almanac information from the CNAV messages in an effort to provide bandwidth for other functions. The working group did not form an opinion regarding this proposal but did note that eliminating the almanac data from the L5 signal may compromise the ability to perform stand-alone L5 operations.
- Boris Pervan presented a paper that described a new methodology for computing the probability of hazardously misleading information. This methodology appears to greatly increase the scale factors used in the computation of protection levels. How that impacts the availability of RAIM and ARAIM is not clear. The working group is requesting Karl Kovach examine the assumptions of this paper.

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

Working Group 2A is inactive and no discussion took place.

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 was continuing to develop performance standards for GNSS-aided inertial systems. This included systems utilizing less accurate Attitude Heading Reference Systems (AHRS) or Micro-Electro-Mechanical systems (MEMS) sensors. Drafts of much of this work was completed prior to this plenary.
- The group has been meeting for some time and the current draft contains sections 1, 2, 3 and 4 including introductory text, requirements and testing guidance, installed equipment performance, and operational performance as well as drafts of appendices A through P.
- Since the previous plenary session, the working group held a series of teleconferences to address the following topics:
 - Alternate trajectory considerations and test recommendations
 - RFI changed to not require use of S/No
 - Online testing clarifications
 - Piece point speed calculations
 - Non-conservative model of ionospheric bubbles based on data collected in Brazil
 - A multi-path model valid down to 2 degrees above the horizon
 - ARAIM compatibility changes
 - HUL incorporated in the HPL definition to make testing more general
 - Plan to use a list of airports for availability testing of terminal and non-precision approach operations
 - Flight profiles for terminal area availability testing
 - Updates of the MOPS draft section 2 to extend the scope and streamline missed detection and exclusion testing
 - Updates of the MOPS draft to rely more on randomized testing for missed detection and exclusion.
- The Japanese Aerospace Exploration Agency (JAXA) discussed a study in which they manually verified the validity of all 1000 observed gradients seen in Japan around the 2014 solar peak. JAXA further noted that the solar peak in 2014 was comparatively weak.
- The working group discussed a new type of testing that is similar to the RAIM testing defined in DO-229() in which 20 detection scenarios and 20 exclusion scenarios are assessed. It was noted that if the detection or exclusion occurs before coasting has begun then the test is no longer valid. The group settled on a set of analysis rules that addresses this issue without impacting systems that use alternative monitors that may correctly detect failures prior to coasting.
- The working group worked to simplify testing associated with ionospheric depletion bubbles. It was determined that a false detection type test would provide sufficient data to bound the cumulative distribution function on a per hour basis at all probability levels. This allows for the removal of a significant set of tests.
- The working group considered the case in which the simulated satellite signals would be based on an aircraft trajectory that is different from that used to simulate the inertial movement. This might be the case when emulating a GPS repeater. The team identified a goal to provide detection of an alternate trajectory and to subsequently provide a bound of the error. This effort is still in progress.
- The working group discussed some of the impacts of multiple ground-based reflectors on surface navigation. The working group's findings were that ground multipath generally cannot induce errors greater than 15 m when the GPS receiver is using a 0.2 chip correlator.

The group hypothesized that larger errors might be experienced if the direct signal is blocked or attenuated.

- The working group spent some time discussing the guidance in appendix L for the use of data from multiple GPS antennas to derive heading. There was some concern that the carrier phase ambiguities cannot be resolved without the use of multi-frequency observations. The working group continues to look for a way to use single frequency observations when only heading and the complete aircraft attitude vector is the desired output.
- The working group has created a series of “robustness tests” that are used to show a “non-objectionable result based on engineering judgement.” These tests include a trajectory passing near the pole, recovery after coasting, fewer than four satellites visible, highly dynamic trajectories as well as reception of low elevation signals that are degraded or lost due to aircraft maneuvering.
- Appendix K contains additional detail for use in the verification of pressure altitude aiding. The appendix provides stochastic models for time, distance and altitude changes used in the development of altitude error estimates.
- The working group considered high fidelity scintillation models that might be used in the verification of velocity accuracy and integrity. No such models exist and future work may be needed to address this.
- Completion of the MOPS remains scheduled for mid-2020. The group will continue to meet throughout the year.
- The working group plans to include appendix F with examples of various integration methods that may or may not include intellectual property. Manufacturers that wish to provide such material will be required to provide a formal authorization to publish the IP but will not be required to provide a commitment to license. The WG 2C chairman will provide a justification for this appendix to the RTCA PMC for the March meeting.

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

Sai Kalyanaraman discussed the Working Group efforts during the week.

- The working group is examining several issues pertaining to the L1 CA link budget. New assumptions for CA-on-CA interference are leading to a negative link margin for receivers designed using the guidance of DO-235B. Receivers designed using the guidance of the proposed DO-235C will not have this problem. WG 6 would like to ask receiver manufacturers to provide details regarding the sensitivity and implementation loss of their equipment so that the analysis can be adjusted using assumptions more in line with real equipment. This data can be provided to Barbara Clark and Hans Trautenberg, who will anonymize the data before providing it to the working group.
- The working group is considering the effects of the requirements of the DO-373 antenna MOPS on the interference mask that the receiver uses. When considering the required design of the antenna it appears that the mask for frequencies below L1 and above L5 may not be as effective as originally believed.
- The working group assessed the impact of pulse blanking on the L5 signal at the WAAS Reference Station Locations. It has been observed that at several stations, and in particular

Honolulu International Airport, the pulse blanking can obscure as much as 31% of the L5 signal. Typical obscuration is on the order of only 5%. The current hypothesis is that multipath signals from nearby TACAN may be causing this greater than expected blanking. This may impact requirements for DFMC receiver's minimum acquisition thresholds.

- ZETA Associates conducted an experiment in which they recorded L5 pulse blanking data as they flew across the continental US. This data was compared with the GREET model and several differences were identified. The working group is working to identify the reasons for these discrepancies.
- The working group presented a plan for the completion of DO-292. Several issues remain to be addressed
 - DME/TACAN
 - JTIDS/MIDS
 - SSR
 - LDACS – this source may prove particularly troublesome. The working group will look into escalating this issue to the ICAO NSP
 - Link budget analysis
 - Interference mask

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

Sai Kalyanaraman discussed the Working Group efforts during the week.

- Working group 7 released the DFMC antenna MOPS, DO-373. No antenna is known to have been designed to comply with this MOPS.
- The working group has realized multipath is almost indistinguishable from azimuthal group delay variation. The errors introduced by group delay variation appear to be significant and may be a limiting factor for GAST D. However, the impacts need to be properly assessed.
- A potential new requirement for the dual frequency antenna may provide a means to drive the design such that the antenna is more resistant to multipath.
- The goal would be for the DFMC to support LPV 200 with a VAL of 10 meters. To support this, an allocation for multipath and group delay variation for the antenna should be developed and flowed down to the antenna developers.

Agenda Item 10. Other Business

- Several members of SC-186, Brenda Perez, Hadi Wassaf and Miles Bellman, joined the plenary committee for a discussion regarding velocity error modeling. The plenary committee discussed that SC-159 will be providing a new means of verifying $NAC_v = 3$ outputs and that is different from what SC-186 is looking for.
- SC-186 is attempting to model GPS velocity errors to support projecting position reports between ADS-B updates. The model they have suggested is a Gauss-Markov process with a standard deviation of 5 m/s (derived from $NAC_v=1$). SC-186 would like SC-159 to confirm that this model is appropriate and also to provide some notion of the required time constant. The model assumes that the velocity could come from ANY GPS receiver without any post-processing. It will only be applied to aircraft (including helicopters) in flight. SC-159 agreed to create an ad hoc working group to provide feedback by April 30th.

Agenda Item 6. Update on ICAO/Navigation Systems Panel

- Barbara Clark discussed fifth meeting of the NSP.
- The NSP has updated job cards with the schedule for the group's products. For example, DFMC SBAS/GBAS ARAIM, Galileo, GPS, GLONASS, and Beidou.
- DS2 subgroup is the DFMC SBAS working group and has a number of objectives including SBAS authentication.
- The GBAS working group is transitioning away from studying VDB interference to the architecture of the DFMC SBAS system.
- All core constellation updates are on the same schedule as the SBAS updates.

Agenda Item 7. Discussion of Terms of Reference Updates

George Ligler led the committee in a discussion regarding changes to the SC-159 Terms of Reference. In an effort to minimize the time required, the committee agreed to forgo editing while in committee.

The committee agreed to update the due dates for DO-235C and DO-292. Mr. Ligler will take these updates to the PMC on March 21st.

Chris Hegarty indicated that the PMC accepted the update of SC-159 TOR in December 2018 approving the schedule changes previously requested by SC-159.

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

The SC-159 plenary discussed the current activities of EUROCAE Working Group 62.

Working group 62 met from December 10th –December 14th 2018.

- Working papers are available at <https://www.eurocae.sharepoint.com>.
- The 47th meeting of WG 62 consisted of three sessions.
- The DFMC SBAS MOPS ad-hoc session addressed the following topics.
 - DFMC SBAS MOPS v0.8 sent for Open Consultation in October 2018
 - 300 comments received
 - Organizations: Airbus, BNetzA, DSNA, EASA, ESA, FAA, Garmin, GSA, MITRE, Rockwell Collins, RTCA, Safran, Thales
 - Level: 51 Editorial, 83 Low, 128 Medium, 37 High (+1empty)
 - Preliminary answers and MOPS update sent to the reviewers on December 4th

- The MC/MF ad-hoc session addressed the following topics
 - The navigation message update rate and SBAS IOD selector
 - A methodology for a receiver to resist scintillation
 - The GLAD project (an ARAIM prototyping activity)
 - The SBAS service area message
 - DFMC SBAS Operation concept (selecting the proper approach type when multiple service types are available)
 - DUFMAN project (dual frequency multipath analysis)
- The MF antenna ad-hoc session discussed L5 band interference activities.
- ED-259 has been published and is available at <https://eshop.eurocae.net/eurocae-documents-and-reports/ed-259/#non-member>
- The next meetings of WG 62 are shown below
 - 13-17 May 2019 (Eurocontrol – Brussels, BE)
 - 10-12 September 2019 (Venue – TBC)
 - 9-13 December 2019 (EUROCAE, Paris, FR) 50th Meeting.

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

These items were addressed throughout the meeting and were not addressed again.

Agenda Item 10. Other Business

Barbara Clark gave a short presentation describing GPS week roll-over. The presentation indicates that the initial reference date for GPS time is Jan 6, 1980. GPS time is represented as a 10-bit week number and a number of seconds into the week. The GPS week number will reset every 1024 weeks. This has happened previously on August 22, 1999 and will happen next on April 6, 2019.

Agenda Item 11. Date and Place of Next Meeting

The 104th meeting will take place the week of September 30th – October 4th, 2019. Working Groups 2, 2C, 4, 6 and 7 plan to meet throughout the week beginning on Monday with the plenary session on Friday morning.

The 105th meeting will take place the week of March 9th – March 13th, 2020. Working Groups 2, 2C, 4, 6 and 7 plan to meet throughout the week beginning on Monday with the plenary session on Friday morning.

George Ligler adjourned the meeting.

-S-
John Savoy
Secretary

CERTIFIED as a true and accurate summary of the meeting.

-S-
Christopher Hegarty
Co-chairman

-S-
George Ligler
Co-chairman