



RTCA Paper No. 212-21/SC159-1100

Washington, 20 August 2021

***Summary of the One Hundred and Ninth Meeting***

**Special Committee 159 (SC-159)**

**Navigation Equipment Using the Global Navigation Satellite System (GNSS)**

The one hundred and ninth meeting of SC-159 was held July 30, 2021, virtually, from 9:00 a.m. to 12:00 p.m., Eastern Daylight Time. The attendees were the following:

NAME	COMPANY
Christopher Hegarty (SC-159 Co-Chairman)	The MITRE Corporation
George Ligler (SC-159 Co-Chairman)	GTL Associates
Wes Googe (SC-159 Secretary)	American Airlines
Barbara Clark (GAR)	Federal Aviation Administration (FAA)
Karan Hofmann (Program Director)	RTCA

NAME	COMPANY
Hamza Abduselam	Federal Aviation Administration (FAA)
Ken Alexander	Federal Aviation Administration (FAA)
John Ashley	The MITRE Corporation
Laurent Azoulai	Airbus
John Barry	Federal Aviation Administration (FAA)
Kevin Bean	The MITRE Corporation
Nuria Blanco-Delgado	European Satellite Services Provider
Michael Biggs	Federal Aviation Administration (FAA)
Ettore Canestri	European GNSS Agency
Mark Dickinson	Federal Aviation Administration (FAA)
Yi Ding	CMC Electronics
Santanu Dutta	Ligado
Bob Earlandson	Lockheed Martin Corporation (Zeta Associates)
James Fernow	The MITRE Corporation
John Foley	Garmin Ltd.
Alex Garcia	Ecole Nationale de l'Aviation Civile
Bob Jackson	Lockheed Martin Corporation
Sai Kalyanaraman	Collins Aerospace
Matthew Lug	U.S. Air Force
Christophe Macabiau	Ecole Nationale de l'Aviation Civile
Mikaël Mabileau	European GNSS Agency

Sean Memme	Federal Aviation Administration (FAA)
Guillaume Novella	Ecole Nationale de l'Aviation Civile
Ajay Parikh	Ligado
Doug Phifer	Federal Aviation Administration (FAA)
Andrew Roy	Aviation Spectrum Resources, Inc.
Jianming She	The MITRE Corporation
John Studenny	CMC Electronics
Dale Swanson	The MITRE Corporation
Hans Trautenberg	EASA
Andrew Videmsek	General Atomics Aeronautics Systems, Inc.
Timo Warns	Airbus
Joel Wichgers	Collins Aerospace

AGENDA

10. Introductory Remarks: RTCA, GAR and Co-Chairs
  
2. Approval of Summaries of Previous Meeting: One Hundred Eighth Meeting for SC-159 held March 25, 2021 (RTCA Paper No. 095-21/SC159-1095)
  
3. Review of DO-235C Final Review and Comment (FRAC) activities
  
4. Decision to approve release of DO-235C for presentation to Program Management Committee for publication
  
5. Discussion of Terms of Reference Updates
  
6. Action Item Review
  
7. Assignment/Review of Future Work
  
8. Other Business
  
9. Date and Place of Next Meeting
  
10. Adjourn

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 \* Barbara Clark, Federal Aviation Administration (FAA), was the Government Authorized Representative for this meeting.  
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**Agenda Item 1. Introductory Remarks: RTCA, GAR and Co-Chairs**

- SC-159 Co-Chairman Dr. George Ligler welcomed everyone to the plenary meeting. Dr. Ligler then introduced the SC-159 leadership team. At this point Dr. Ligler paused to note the passing of Larry Chesto, a former chair of SC-159. He indicated that we would have an agenda item at the next plenary session to properly honor Mr. Chesto's passing with the

group. Dr. Chris Hegarty echoed these comments.

- Karan Hofmann, SC-159 Program Director at 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 Plenary meeting is open to the public, 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 chairmen and program director. Karan also discussed meeting "tips" for virtual meetings using WebEx. Ms. Hofmann then proceeded to identify several call in numbers for the meeting attendance list.

## **Agenda Item 2. Approval of Summaries of Previous Meetings.**

- a) The summary for the 108<sup>th</sup> meeting of SC-159, RTCA Paper No. 095-21/SC159-1091, dated 26 March 2021, was presented to the meeting. Meeting attendees were asked to review the summary and provide any comments to RTCA.
- b) Dr. Hegarty commented that the minutes reflected that Laurent Azoulai was introduced as the Chair of EUROCAE WG62 when instead he is a member of the TAC leadership for this body. It was noted and the minutes will be amended to reflect this.
- c) Barbara Clark, the FAA's GAR for SC-159, offered her thanks to the members of WG6 who put in a lot of time into this document in order to prepare it for approval today.
- d) After these comments Dr. Ligler asked for any additional changes or comments. **No comments were received and the summary was approved.**

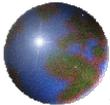
## **Agenda Item 3. Review of DO-235C Final Review and Comment (FRAC) activities**

Dr. Ligler introduced Dr. Sai Kalyanaraman to review progress made by the group in regards to FRAC comments received and dispositioned. Dr. Kalyanaraman thanked the work group members for all the time and effort put into completing the FRAC process. He then gave a high-level overview of their work, FRAC updates and a path forward for FRAC completion via a slide presentation.

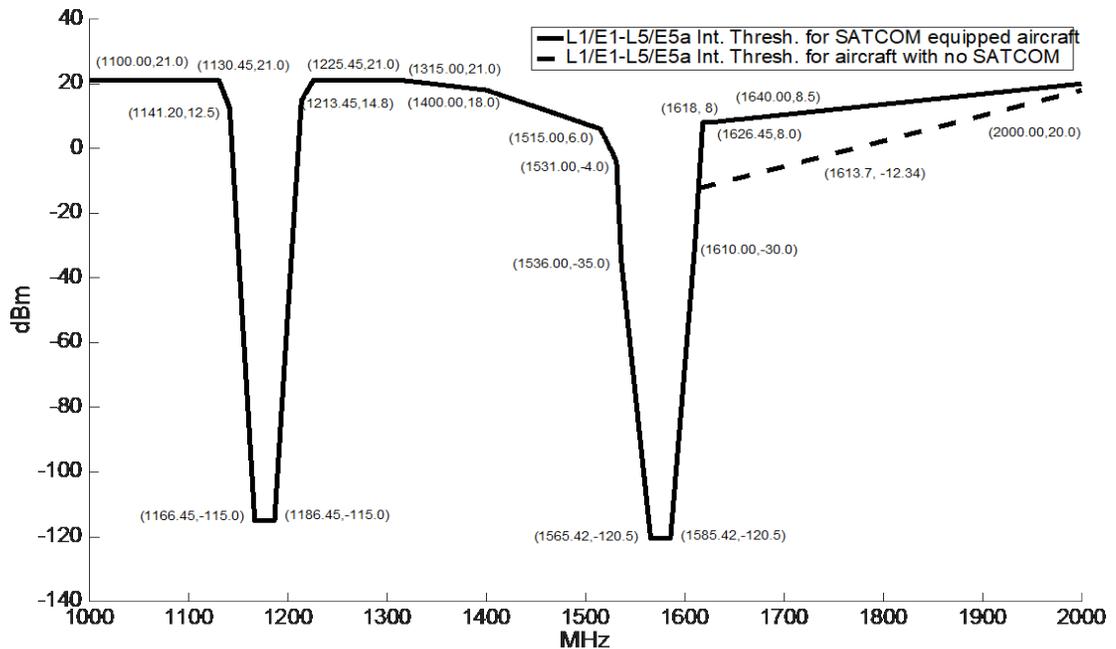


# DO-235C

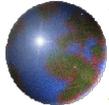
- Assessment of RFI relevant to the GNSS L1 Frequency band
- Addresses both GPS L1 C/A and Galileo E1 b/c.
- Updated link analyses in line with the latest SiS specifications.
- Improved aggregate terrestrial RFI modeling to refine non-aeronautical emitter impacts to SoL GPS L1 and Galileo E1 signals.
- Revised GNSS Inter and intra system assessment in support of updated link analyses
- Updated RFI mask (for both L1 and L5 bands)
  - Additional resiliency to RFI from Iridium Certus
  - Additional resiliency to RFI in the band below GPS L1/Galileo E1
  - Resiliency of L1/E1 processing channels to additional non-aero interference in the L5/E5 band

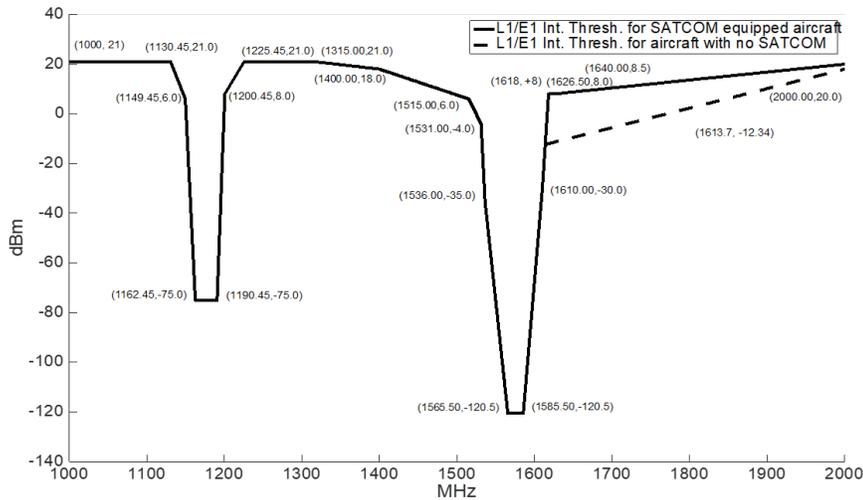


## CW Interference Thresholds for GPS L1/L5, Galileo E1/E5A, DFMC SBAS Receivers



Dr. Kalyanaraman remarked as to chart above that if DFMC systems comply with the proposed mask requirements, then these systems should be able to coexist with Iridium operations. This mask then should be the answer for continual L1/L5 operations. He then moved to the next slide.

 *Interference levels at antenna port for GNSS L1/E1 Processing channels*

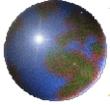


Barbara Clark then offered a few questions. She first asked if it were true that one could Track an L1 signal if there was interference on L5 and vice versa? The she then asked if he could comment on whether this capability could be achieved with the current level of interference that the government creates in certain sponsored exercises. Dr Kalyanaraman was not certain of the impact given he was not familiar with the specifics (power levels, impact radius etc.) of this interference testing. He felt it would be better from a MOPS perspective, but it was difficult to fully answer the question from what we have for equipment today to where we will be in the future. He did feel that systems would be more resilient.

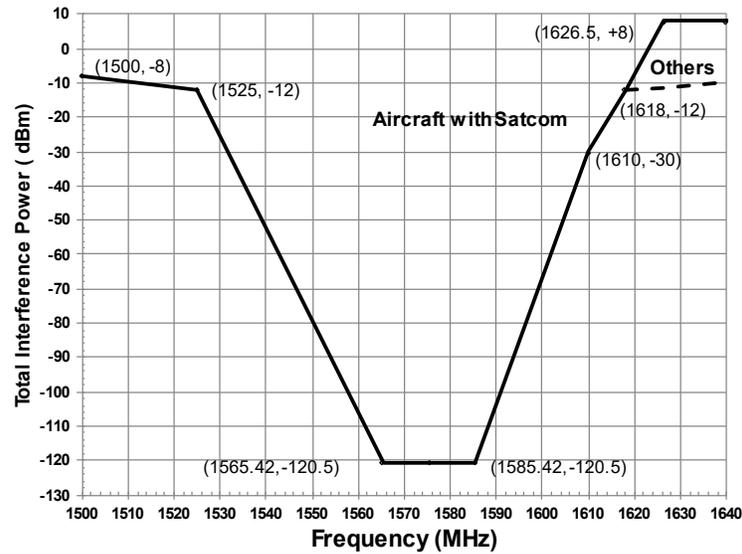
Ms. Clark then offered that there should be a claim of Dbs of margin improvement, but Dr. Kalyanaraman couldn't speak to a specific number. She agreed.

Dale Swanson then asked the group to look back at the previous slide. He remarked that this slide shows levels of interference that are acceptable for continual L1/L5 operations.

He then remarked that the next slide shows that with the loss of L5 one should still be able to operate on L1/E1. The group had a fair amount of discussion on how the receiver processes would work to support this operation. Dr. Kalyanaraman then moved to on to the next two slides.



## Interference Levels at the Antenna Port for SF GPS L1



## GPS and Galileo noise levels

Receiver Function	Effective Noise Density (dBm/Hz)*
GPS Enroute Acquisition and Tracking** <sup>1</sup>	-168.24
GPS Tracking and Re-acquisition	-169.01 <sup>(2)</sup> , -168.80 <sup>(3)</sup>
SBAS Tracking and Re-acquisition <sup>4</sup>	-169.24

\*Value assumes the satellite signal generates only the GPS and QZSS IGSO L1 C/A signals. Military and L1C GPS signal effects are included in the PSD value.

\*\* In the presence of many GPS signals, it is assumed that the receiver will acquire GPS satellites first so that an SBAS signal is not necessary for enroute acquisition.

Note 1: Value for N-LYI enroute scenario (see details below).

Note 2: Value for W-LYI precision approach (see details below).

Note 3: Value for Baikal precision approach (see details below).

Note 4: Value for high latitude (MEH) SBAS precision approach.

Receiver Function	Effective Noise Density (dBm/Hz)
Galileo Enroute Acquisition and Tracking <sup>5</sup>	-167.92
Galileo Tracking and Re-acquisition <sup>6</sup>	-167.92

Note 5: Value for high altitude scenario (7.5°N, 122.5°).

Note 6: Value for ZAM precision approach.

For this slide Dr. Kalyanaraman indicated that Appendix F had been updated with revised noise levels. L1 GPS C/A and Galileo E1 noise levels had evolved based on analysis and L1 C/A levels have seen some preliminary vetting by receiver manufacturers based on sensor testing with hardware in loop. He commented that Galileo testing will be more in line with DO-229() while L1 testing is more constrained due to the specific nature of the doppler crossovers at

given space time points. He added that more discussion would be had on how to structure these test procedures. Then he moved to highlights of FRAC work to this point.



## Highlights of FRAC

- ⊕ Need to review Satcom Emissions data from Airbus and determine if we need to update the current estimates for Io, AMSS allocation.
  - ⊞ If the numbers are higher than what we see in DO-262, we will plan to liaise with SC-222 to help resolve. This will be carried as a recommendation.
- ⊕ There are multiple instances where the link for the GPS L1 C/A sensor goes marginally negative per the analysis.
  - ⊞ Based on earlier sensor testing under the specific S-T points, three receiver manufacturers have not seen issues with GPS L1 C/A tracking under these conditions.
  - ⊞ We will carry a recommendation for receiver test and validation under listed signal and noise conditions at the hotspot.
- ⊕ Updates to Figure F-2 (Intfc levels at antenna pot for L1 channels)
- ⊕ Updates to Table F-6 (GNSS Noise for GPS L1 C/A processing)
- ⊕ Need to Resolve usage of Google map picture in DO-235C

Group discussion followed this slide with Mr. John Foley commenting that it is understandable to protect the resiliency of L5 that there would be a need to give up resiliency for L1. Mr. Swanson added that this is not a requirement for receiver manufacturers but guidance to support DFMC receivers. This document should help those that have to handle L5 jamming (to a limited extent).

Dr. Kalyanaraman then brought up a subject in reference to using Google copyrighted maps in RTCA documents. Ms. Karan Hofmann looked at an example that Dr. Kalyanaraman displayed and she offered that if the document were not for sale then it should be okay but if it were for public sale then that would be a problem. Since RTCA documents are sold to non RTCA members, this poses a problem for RTCA. Mr. Swanson indicated that to ask Google for permission would create prohibitive delay for the completion of the document, so we need to bring up at the next plenary resolve or use government maps. This would be an on-going problem if not resolved. Dr. Ligler then commented that we need to get permission or use another document. Dr. Hegarty agreed with this assessment. Mr. Hans Trautenberg asked if a government map was suitable to use to overlay WG6s results instead of a Google map? Bob Earlandson indicated that to redo his work he would rather get a large overview map and redo without Google maps. Dr. Kalyanaraman asked if it was the group consensus to get another image and Dr. Hegarty responded in the affirmative. Dr. Ligler suggested to use a gov't picture but then engage Google on a broader scale to get permission to use their maps in aviation standard documents.

Ms. Clark then questioned section four of the document. Mr. John Barry submitted comments on this section and she wondered how this would be resolved in spite of a changing environment. Dr. Kalyanaraman planned to have all these low to medium comments resolved

in the next few days. Ms. Clark then asked him if the group needed reach out to the maritime folks mentioned in section four. The language had been kept from DO-235B through DO-235C. She asked if it needed to be updated by going back and contacting outside commenters or just have a disclaimer that this language remains the same due to scope. Dr. Kalyanaraman indicated that the committee would address the topic and if recommended would find out from original commenters if there were a need to update. Mr. Barry agreed with this way forward. Mr. Earlandson also added that this information had been there since DO-235A when the DOT first directed that it be included.

Mr. Swanson then revisited concerns over contacting Google to ask permission on using their maps in RTCA documents. Mr. Ken Alexander remarked that there were other alternatives and offered a website for government maps:

[https://www.faa.gov/air\\_traffic/flight\\_info/aeronav/productcatalog/vfrcharts/](https://www.faa.gov/air_traffic/flight_info/aeronav/productcatalog/vfrcharts/)

These could be used but scale had to be taken into account. As Mr. Swanson reviewed this type, he commented that this should be a better option.

Then Dr. Kalyanaraman moved to the last slide of the presentation.



- Opened FRAC on 6/23/21
- Closed FRAC on 7/23/21
- Total Comments – 681
- Non – Concur : 1
- High : 56
- Medium: 68
- Low: 165
- Editorial: 391
- Resolved all non -concur and high comments.
- Working on the med , low and editorial comments.
- Resolved a total of 200+ comments to date.
- Do not see a blocking issue to successful resolution of the remaining comments in the next couple of days.
- Plan to provide the updated document to RTCA (Karan Hofman) before end of next week.
- Request plenary approval to resolve remaining med, low and editorial comments offline and submit document for PMC review.

He indicated that the committee had resolved all the High comments and were working on the low and medium comments to be ready by end of next week. Mr. Foley asked if some of the late changes in GNSS numbers should be used to update referenced numbers and tables in the document. Dr. Kalyanaraman answered that the changes would be minor and that some analytic work had already been done with changed DFMC numbers but while all tables had not been updated yet some had been. In particular he referenced that Tables 13-2a & 13-2b were updated along with Tables 13-3a, 13-3b, Tables 13-10 to 13-13 and Tables 13-4 to 13-9 to reflect updated GNSS noise assumptions that would impact link budgets. This in turn resulted in updates to Table F-6 for GPS L1 C/A processing. Table F-7 would also be modified to reflect the updated noise assessment for Galileo. Then there was a general discussion on

how to adjust these tables due to the changes in the IGSS numbers.

Mr. Christophe Macabiau asked if while the committee was discussing these updated numbers were all the tables updated for Galileo. Mr. Earlandson responded that all were not updated due to time, but they would be before the end of next week.

Ms. Hofmann then asked if a plan had been prepared if any unresolved comments ended up moving to a higher level. Dr. Kalyanaraman responded that he would bring these to the larger group for their situational awareness, but he did not anticipate that happening or an inability to resolve comments requiring plenary action.

#### **Agenda Item 4. Decision to approve release of DO-235C for presentation to Program Management Committee for Publication**

Dr. Ligler then asked the plenary to vote on the DO-235C document as presented. He asked that if there were any difficulty in resolving either low or medium comments and fixing the Google map issue, let us know as quickly as possible. The Group agreed to accept the document without comment. The plenary approved the document to forward to the PMC for the September 16<sup>th</sup> meeting. Ms. Clark then asked about an item of coordination with SC-222 on the Airbus Satcom Issue. Dr. Kalyanaraman responded that their comments would have to be resolved. Dr. Ligler added that it needed to be determined if SC-159 or SC-222 needed to solve this Problem. Dr. Kalyanaraman felt they considered their comments but while he feels it is Issue to resolve, WG6 will develop language to bring to the PMC on this issue (if needed).

#### **Agenda Item 5. Discussion of Terms of Reference Updates**

There were no ToR updates.

#### **Agenda Item 6. Action Item Review**

Dr. Ligler asked for any action items to be brought forward. None were presented.

#### **Agenda Item 7. Assignment/Review of Future Work.**

Dr. Ligler asked if there was anything else that needed to be brought to the PMC. Nothing was noted.

#### **Agenda Item 8. Other Business**

Ms. Clark referenced that future work would be needed to respond to the ICAO state letter that had been received by the FAA. She asked if WG6 had reviewed the ICAO document which Dr. Kalyanaraman responded to in the affirmative. The timeline of the response was discussed amongst the group and Mr. Mikael Mabilieu stated that a response was due to ICAO by January of 2022. He further asked if WG6 planned to a paper to the ICAO NSP. Ms. Clark added that the WG had been updating the secretariat of their work. Mr. Laurent Azoulai suggested that a detailed paper be presented by WG6 to ICAO. Dr. Kalyanaraman responded that a coordination paper would be presented to the ICAO panel in November of 2021. Dr.

Ligler asked if this could be completed for disposition by the October plenary and the group felt that it could.

**Agenda Item 9. Date and Place of Next Meeting**

- The next full SC-159 gathering (to include the 110<sup>th</sup> Plenary) will take place the week of October 18<sup>th</sup> – 22<sup>nd</sup>, 2021.
- The subsequent gathering (to include the 111<sup>th</sup> Plenary) is scheduled for the week of March 28<sup>th</sup>-April 1<sup>st</sup>, 2022
  - Dr. Ligler indicated that group would tentatively plan for a face-to-face meeting in Washington DC at RTCA subject to COVID restrictions although a WebEx would still be available as always.

**Agenda Item 10. Adjourn**

Dr. Ligler thanked all participants and adjourned the meeting.

CERTIFIED as a true and accurate summary of the meeting.

-S-  
Dr. Christopher Hegarty  
Co-chairman

-S-  
Dr. George Ligler  
Co-chairman