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EUROCAE WG-119 Plenary Meeting #5 “Radar Altimeter” / RTCA SC-239 Plenary Meeting #5 “Low Range Radar Altimeter”

DATE: Sep 8-9, 2021

TIME: 9 AM – 1 PM EDT

PLACE: Virtual

CONTACTS:

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AGENDA

1. Welcome, Introduction and Agenda - Jean-Luc
3. EUROCAE/RTCA présentations and policy - Rebecca, Karan, Anna
4. Round table and detailed agenda for SG – Jean-Luc
5. Review of Minutes from the previous plenary – Sai
6. MOPS Status and date for the next plenary – Jean Luc
7. SG4 Status and Update: Samh Menshawy
8. SG2 Status and Update: Kim
9. SG5 Status and Update: Dave Redman
10. SG1Status and Update: Ore and Charisse
11. SG3 Status and Update: Miles Bellman
12. SG6 Status and Update: Timo Warns
13. ECC Presentation – Gerhard Berz
14. O’hare approach scenario – detailed write up
15. Other business, action item review
16. Adjourn

PARTICIPANTS

Name	Company
Andrew Roy	ASRI
Angela Roth	Airbus
Anna Guegan	EUROCAE
Anne Lena Vaske	TU-Bransceig
Ashu Pande	NexNav
Barbara Clark	FAA
Charisse Green	FAA
Charles Glass	NTIA
David Redman	AVSI
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Ed Hahn	ALPA
Eddie Straub	Garmin
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Matt Harris	Boeing
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Samh MENSHAWY	Thales Group
Sergio Machado	ANAC
Seth Frick	Honeywell
Shunichi Futatsumori	ENRI
Simon Atkinson	Roke
Ted Peterson	Collins Aerospace

Thomas (Wes) Googe	American Airlines
Tim Murphy	Boeing, Inc
Timo Warns	Airbus, Inc
Tomas Beda	Honeywell
Uwe Schwark	Airbus
Zhimin Li	Collins Aerospace

1. Welcome, Introductions and Administrative Remarks

After a round-table of introductions, the co-chairs Jean-Luc and Seth Frick along with Karan Hoffman and Rebecca Morrison from RTCA and Anna Guegan from EUROCAE welcomed the participants. Anna and Karan presented the RTCA and EUROCAE IPR and other policies.

2. Agenda Review

The group reviewed and approved the meeting agenda.

3. Plenary Discussions

Jean Luc provided the master agenda for the meeting and the group reviewed the RTCA and EUROCAE policies.

Sai presented minutes from previous plenary meeting. This was shared with the group for further review and comment.

Jean Luc presented the outline of the MOPS document sections in a table with columns to indicate what the status is and tried to estimate the workload for the remaining scope of work. Provided a slide on SC-239 / WG-119 planning towards compiling the MOPS document.
There is a fair amount of work to be done on the updated loop loss description. Another item with a high level of work demand is the compilation of the ITM. Focus for fall’21 is to look at potential ITM relaxation (with the top – down approach). We want to leverage what is allowed by state of the art filtering in a viable state of the art sensor. This is a risk that the team needs to retire soon. (Mitigate or avert the risk.) Once we complete this, the team can work on test procedure discussions.

Next plenary is slated during the week of - 1/31/22. It is anticipated to be a hybrid event. Exact date and time are TBD.

SG4 Discussions:

Samh presented his updates on his drafting of the MOPS outline where he addresses the system performance envelope (alt range, pitch and roll angles, velocity (vert and horz), reflectivity and loop sensitivity). He outlined the different equipment performance classes (alpha through delta). And also addressed some of the equipment performance criteria (such as accuracy as function of equipment class) and the standard antenna performance criteria (outlining values for peak gain, beamwidth, bandwidth, VSWR, SLL, Isolation, OOB Gain). Next steps included review of updated Scn. 2.2.3, Loop sensitivity calculation method, complete standard antenna performance criteria, env req, test procedure definition and requirements compilation.

SG2 Discussions:

SG2 discussions focused on identifying the 5G RF threats. Kim provided an updated list of the currently understood 5G emission limits set by national regulators (based on global 5G roll out plans). SG2 is going back and will plan to verify the data on BS emissions limits. They plan to approach the verification by attempting to tie the BS Emission numbers back to existing regulations. Typical info often provided and needs to be validated via further evaluation. US, UK, France and overall European BS regulatory emissions limits have been confirmed, but the specifics of BS deployment parameters still need to be investigated.. We need to confirm China and Japan. Discussions ensued on what values we may put into the appendix re: the 5G Emissions (OOB and IB). There was consensus that we will need to better understand how much LRRA's can tolerate in the end state when 5G / future G's keep evolving in the adjacent band. Team plans to share the current set of BS emissions mask info for consideration at the upcoming ICAO FSMP.

Action: discuss what needs to be shared at FSMP.
Action: what to share for a later FSMP meeting re: ITM (Interference Tolerance Mask). This will be a discussion within SG5 as we move forward.

Discussion ensured on the ITM vs. what its implications are for design margins. Sensor Design margins are typically over and above this ITM and are not transparent to the end user. This is something that aviation OEM manufacturers will need to account for internal to their design and manufacturing process towards ensuring that each sensor will meet its necessary performance requirements (in the presence of interference at levels up to the ITM).

9/9/21

Jean luc opened the meeting and shared a slightly updated agenda for the day.

SG1 Discussions:

Ore presented the updates on the generic continuity and integrity trees that were created for rad alt use cases and derived integrity and continuity reqs. for interference detection mechanisms.

For cat 3 operations, they estimate that Pmd < 1e-3 (within exposure window) , the Pfa (or incorrect detection) <= 1.2 e-6 /FH

Discussions on definitions of continuity and integrity ensued along with further discussions on the failure scenario descriptions.

Action: Richard Amy to provide details on existing standardized failure definitions.

Shared the LRU functional Interface continuity tree, 10 % allocation to RFI contributions which could impact continuity. The allocation was based on the AC 120-28D: Criteria for approval of category III weather minima for take-off, landing and rollout.

Further discussions ensued between Seth, Sai and Ore on the allocation of prob of failure for the interference detection mechanisms.

Action: Ore to setup an SG1 meeting to discuss this further and bring the above mentioned discussions to its logical conclusion.

SG3 Discussions:

Miles Bellman presented the status of work with SG3 and also shared a draft of the MOPS section SG3 has proposed to address the RF transmission spec for the rad alt. This spec will be defined as a conducted emissions value vs. radiated emissions. Draft with reqs are available on Aeropus under the SG3 folder for review and feedback. These are in Section 2.2.5.1. Miles provided a detailed description of Table 2-1 and the plot of attenuation vs band edge offset for different transmit power levels.

Next steps are to compile a test procedure that corresponds to 2.2.5.1. RF Emissions requirements. Need input from rad alt manufacturers to help validate the test procedures.

SG6 Discussions:

Timo Warns presented updates on the SG6 proceedings from previous SG6 meetings. He presented the security performance requirements for a suite of different conditions including high power signals in the rad alt band (Pinv – to be addressed based on power level and loop loss).

He then shared proposed reqs for integrity in the presence of RF Interference. Team had a fair amount of discussion around this requirement. Timo provided further clarification on the RFI scenarios are addressed under this requirement.

The group discussed the case of encountering highly coherent (but spurious) signals (below Pinv) and the relevant requirements on rad alt recovery after this condition subsides.

The SC-239 Group is invited to review and comment on the security performance requirements presented during plenary. Further discussions around these are envisioned in follow on SG6 meetings.

Gerhard Berz presentation:

Gerhard provided the background on CEPT. He added that the rad alt – 5G interference (3.4 – 3.8 GHz) compatibility report is being compiled by ECC (under PT1) and he asked for input from rad alt manufacturers to this end. SC-239/WG-119 members stated that we can offer the existing 5G compatibility data (with interference in 3.7-3.8 GHz) as a start and added that we could share the data on the rest of the frequencies as a follow up to the same.

As regards the data on the 3.7 – 3.8 GHz interference data set, there was a question on whether we can provide this to PT1 by reference to the RTCA report. Gerhard added that referencing the report is welcome, but that actual text quotes and figure extracts would be desirable. It is to be noted that we will need RTCA permissions to lift material out of the report and share/use further.

Actions: Meeting with Karan, Anna, Seth, Jean Luc and Terry to determine how to move forward on this request. How to address ECC membership? (This is the up to RTCA/EUROCAE leadership.) Gerhard Berz requested that the group Review and provide feedback on chapter 3 of the word attachment (titled: “Working doc on draft ECC Rep Radio altimeters_ECTL00.docx “). He also added that ECTL is open to potentially taking up feedback from the SC-239/WG-119 group back to PT1. This will need further discussions as we move forward.

RTCA Report Errata:

Seth provided an update on the errata to the report. The only change is the correction of the noted location of a single simulated 5G tower for the approach scenario which was a typographical error in a table (for FCC Registration ID 1256593). . The change has no material impact to the key conclusions in the SC-239 report as the correct location was used in the analysis, but there was a transcription error which appeared in the table. Seth provided a short write up that explained this change.

Seth also presented to the group an explanation on what he presented to the FCC as further clarifications to the RTCA report when requested by the FCC. This presentation is to make all SC-239 members aware of the context and discussion. The information is attached following these minutes.

4. Future Meetings
    a. Next joint plenary with EUROCAE WG-119 will be on the week of the 31st of Jan. Specific dates in this week are yet to be identified. It is anticipated that this will be a hybrid meeting.
    b. Other Actions – (over and above what has been mentioned in the main body of the minutes) will be updated in the final version of the minutes.
5. Adjourn
   The meeting adjourned around 1 PM ET on the 9th of Sep 2021.

O’Hare RWY 27L Approach Scenario Analysis Details

Seth Frick
Sr. Radar Systems Engineer
Honeywell Aerospace

June 17, 2021

Introduction

As with all of the analysis contained within the RTCA SC-239 5G interference report, the O’Hare approach scenario utilizes the following source-path-receiver model as described on page 12 of the report (Equation 6-2):

$$PSD_{RX} = PSD_{source} + G_{source} - L_{prop} + G_{RA} - L_{RX}$$

Base Station Power

In the O’Hare approach scenario, all five of the base stations analyzed are assumed to be of the Urban 16 x 16 AAS type. The operational characteristics for this base station configuration are listed in Table 6-4 on page 21 of the report. This includes a conducted power of 25 dBm (peak) per element, resulting in the following total peak conducted power for the AAS array:

$$P = 25\ dBm + 10\log_{10} 256 = 49.1\ dBm$$

Each base station is assumed to operate with a downlink channel bandwidth of 100 MHz, to correspond with the testing conditions used to determine the empirical interference tolerance thresholds for the radar altimeters (the 5G fundamental emissions tolerance thresholds are measured using a 5G waveform with a 100 MHz channel bandwidth). In addition, each base station is assumed to operate with a downlink activity factor of 50%. Therefore, the **average** conducted PSD from each base station is:

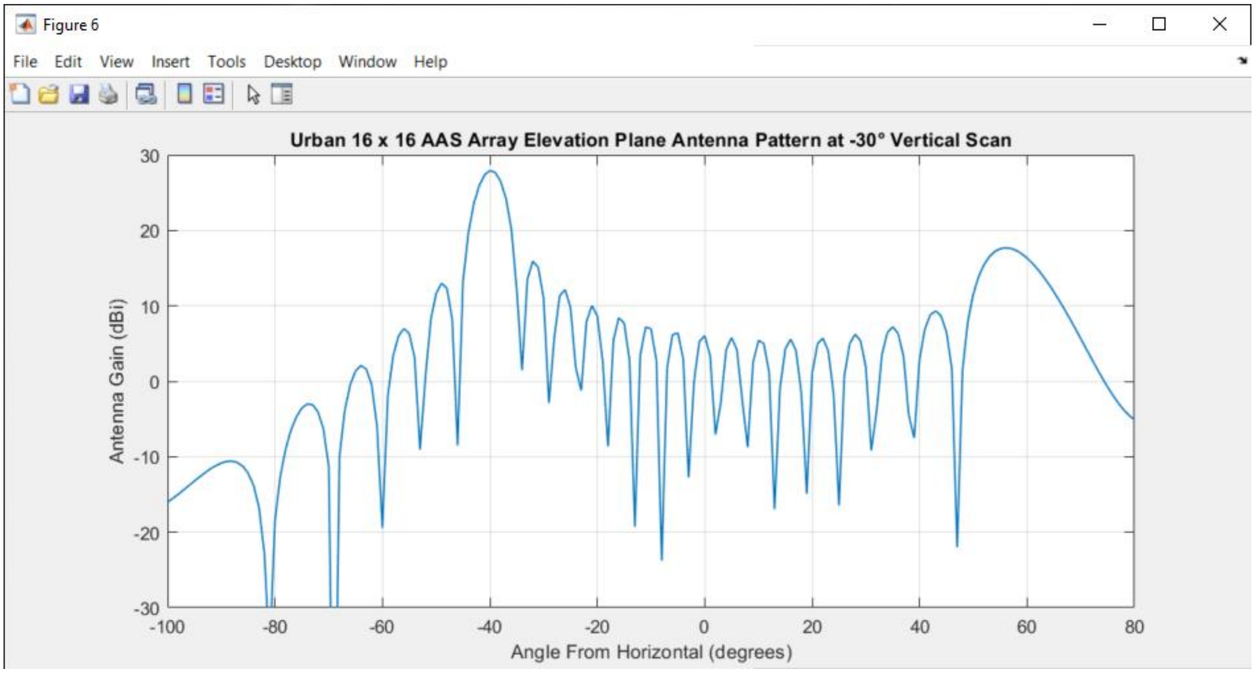
$$PSD_{source} = 49.1\ dBm - 10\log_{10} 100\ MHz + 10\log_{10} 0.5 = 26.1\ dBm/MHz$$

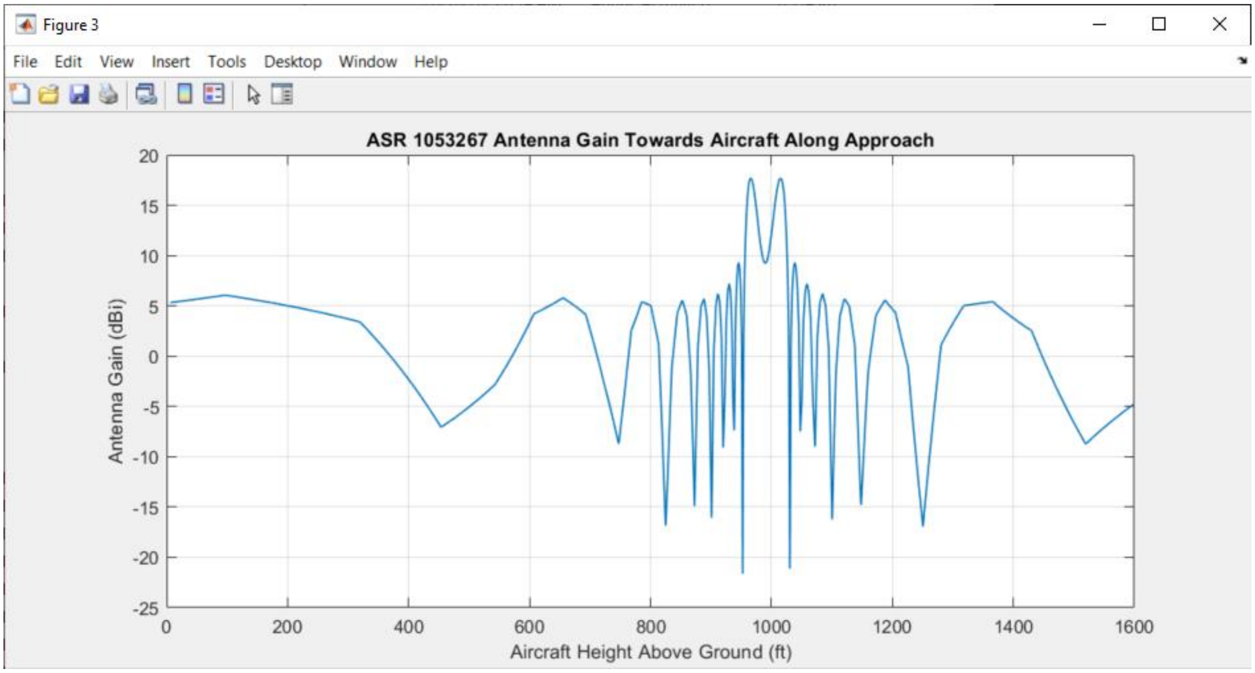
Base Station Antenna Gain

The base station antenna gain, G_{source}, must be calculated based on the relative geometry between the base station and aircraft, as well as the assumed base station characteristics including AAS scan angles. The base station antenna patterns are computed in accordance with Recommendation ITU-R M.2101-0, using the parameters listed in Table 6-4 (16 x 16 array, 6.4 dBi element gain, 90 degree horizontal element beamwidth, 65 degree element vertical beamwidth, 30 dB front-to-back ratio, horizontal array spacing coefficient of 0.5, and vertical array spacing coefficient of 0.7). All of these parameters were provided by wireless industry experts in the TWG-3 information exchange. It is further assumed that the azimuth angle from the base station to the aircraft is zero <u>at all points along the approach</u>. This means that the resulting calculated interference levels from each base station represent the worst-case levels that could be expected from that base station based solely on its placement relative to the flight path, regardless of the actual sectorization, azimuthal orientation, and horizontal AAS scan angles utilized by the base station in any one particular instance. Therefore, the base station antenna gain values are computed at each point along the approach based only on the elevation angle to the aircraft as observed from the base station mast.

Since the base station antenna pattern in the elevation plane (that is, a pattern cut at broadside/zero degrees azimuth) changes based on the AAS vertical scan angle, a specific vertical scan angle assumption must be made. In the technical information provided originally by the wireless industry experts in TWG-3, it was asserted that the Urban 16 x 16 AAS array base station configuration would have a vertical scan angle range from -30 to 0 degrees, defined relative to the array broadside direction. That is, this angle is additive with the mechanical downtilt to define the AAS main beam scan direction relative to the local horizontal. For the Urban 16 x 16 AAS base station with 10 degrees of mechanical downtilt, this means that the minimum vertical scan angle of -30 degrees corresponds to the main beam being directed to 40 degrees below the local horizontal plane. As shown in Figure 6-4, the -30 degree vertical scan case leads to a grating lobe in the antenna pattern directed above the horizon. As a result, this AAS vertical scan angle leads to the worst-case interference levels seen by the aircraft throughout the approach, and thus all five base stations were assumed to be operating with this vertical scan angle for the analysis summarized in Figure 10-33.

As an example, the following plots illustrate the base station antenna gain in the elevation plane with this vertical scan angle assumption, and the computed base station antenna gain in the direction of the aircraft throughout the full approach for the base station ASR 1053267.

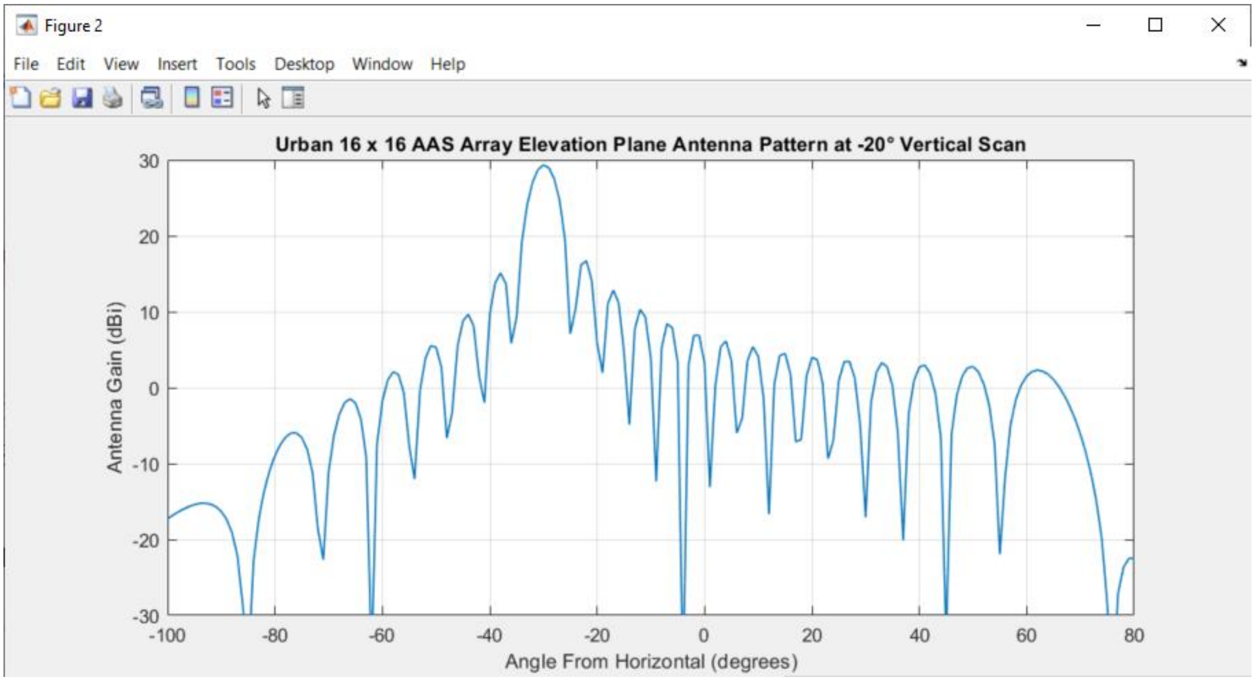


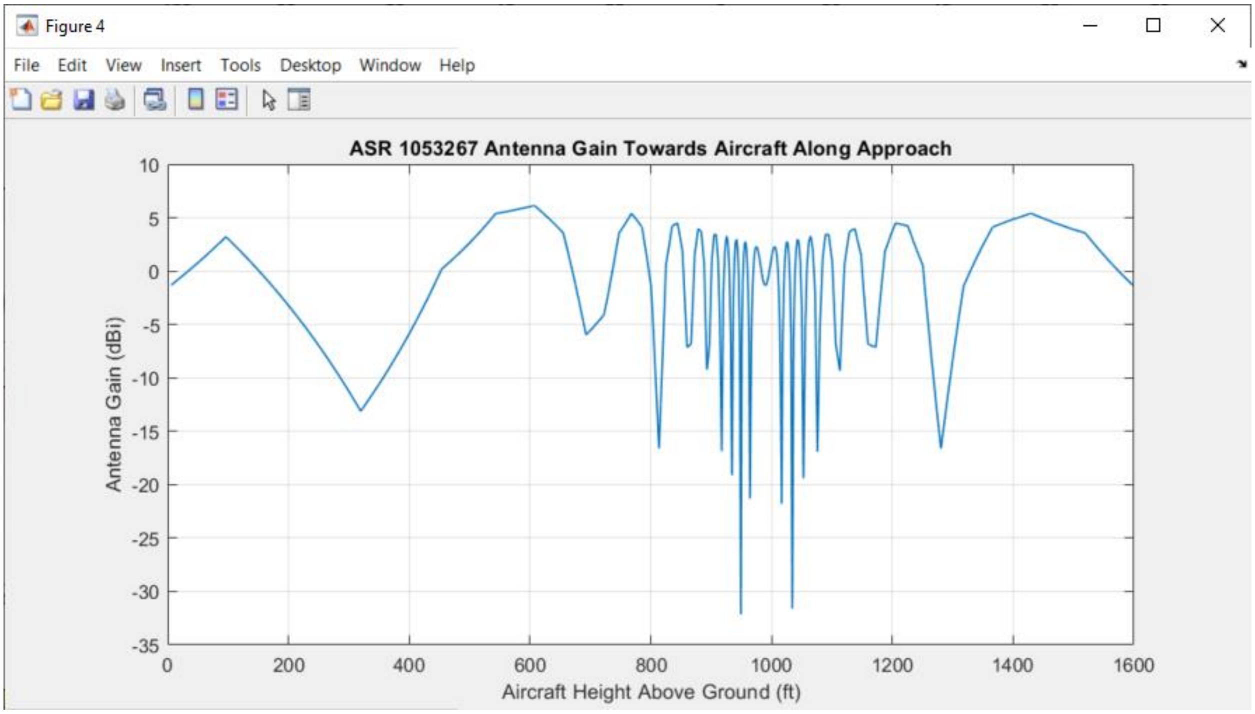


As described in Appendix D, during the open review and comment period for the SC-239 report, CTIA provided a comment indicating that the reference for the AAS vertical scan angles that had been originally provided in the TWG-3 information exchange was incorrect, and that it would instead be more appropriate to consider these ranges to be inclusive of the mechanical downtilt. That is, a -30 degree vertical scan angle would correspond to the main beam being directed to 30 degrees below the local horizontal plane, and for the Urban 16 x 16 AAS (with 10 degrees of mechanical downtilt) this would further correspond to the scan angle being just -20 degrees relative to the array broadside direction.

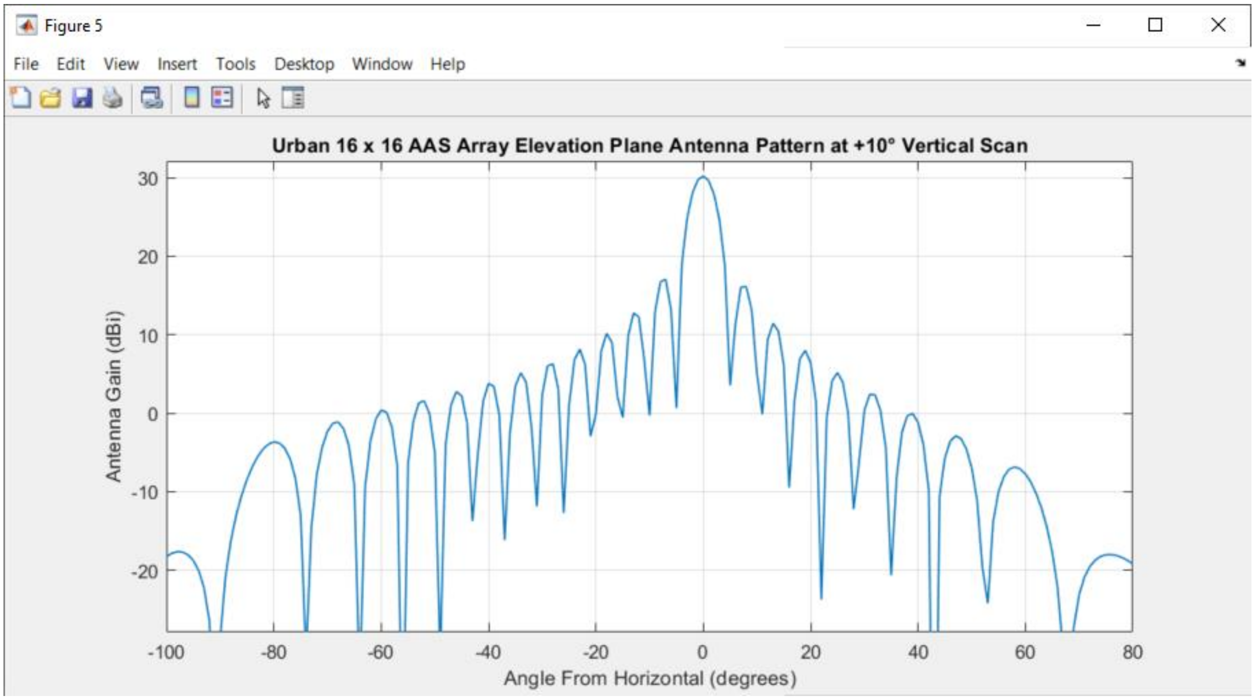
Because the wireless industry experts and CTIA could not confirm that their correction to the vertical scan angle assumptions represented a true operational restriction for 5G base stations, but was instead simply meant to be more representative of typical anticipated operations, the analysis contained within Section 10 of the main body of the report was left unchanged. However, all of the affected analysis scenarios were reevaluated with this updated assumption, with the results compiled in Appendix D (noting that the overall conclusions of the report were not affected by the change). The O’Hare approach scenario was reevaluated with two different vertical scan angle assumptions: a -20 degree scan angle relative to the array broadside direction (30 degrees below the local horizontal), shown in Figure D-15, and a +10 degree scan angle relative to the array broadside direction (along the local horizontal), shown in Figure D-16.

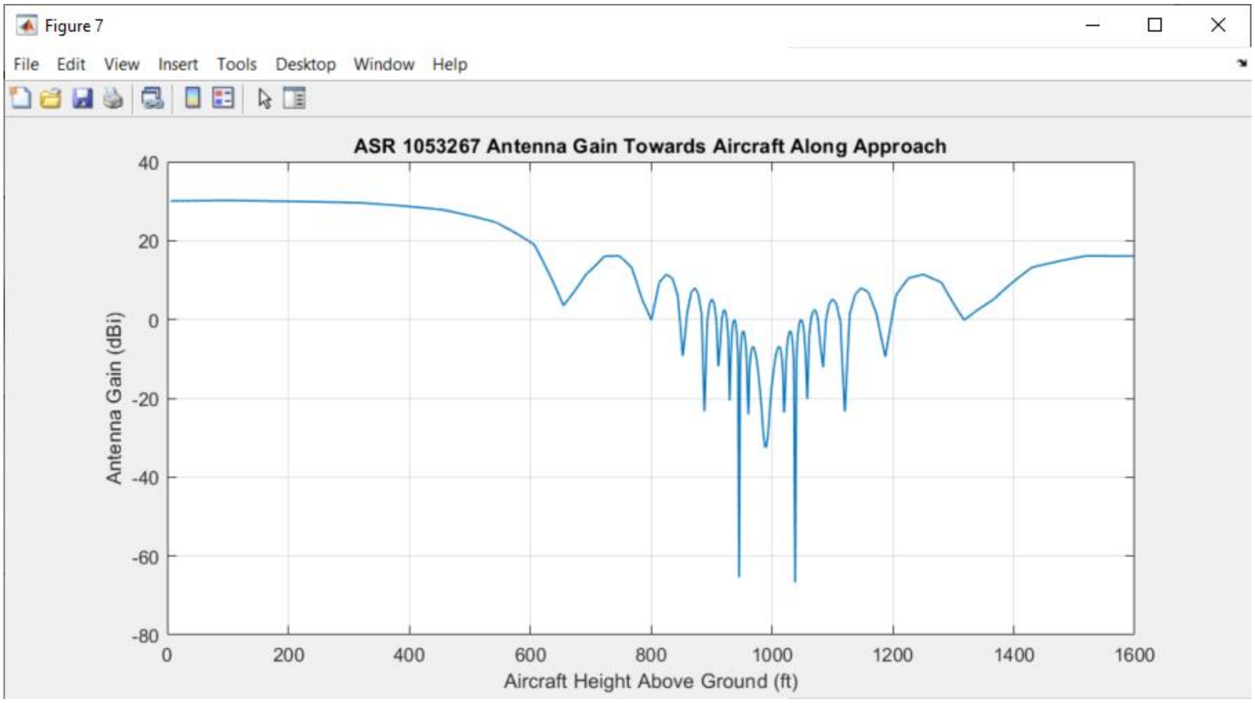
The following plots illustrate the base station antenna gain in the elevation plane with the -20 degree vertical scan angle assumption, and the computed base station antenna gain in the direction of the aircraft throughout the full approach for the base station ASR 1053267.





The following plots illustrate the base station antenna gain in the elevation plane with the +10 degree vertical scan angle assumption, and the computed base station antenna gain in the direction of the aircraft throughout the full approach for the base station ASR 1053267.



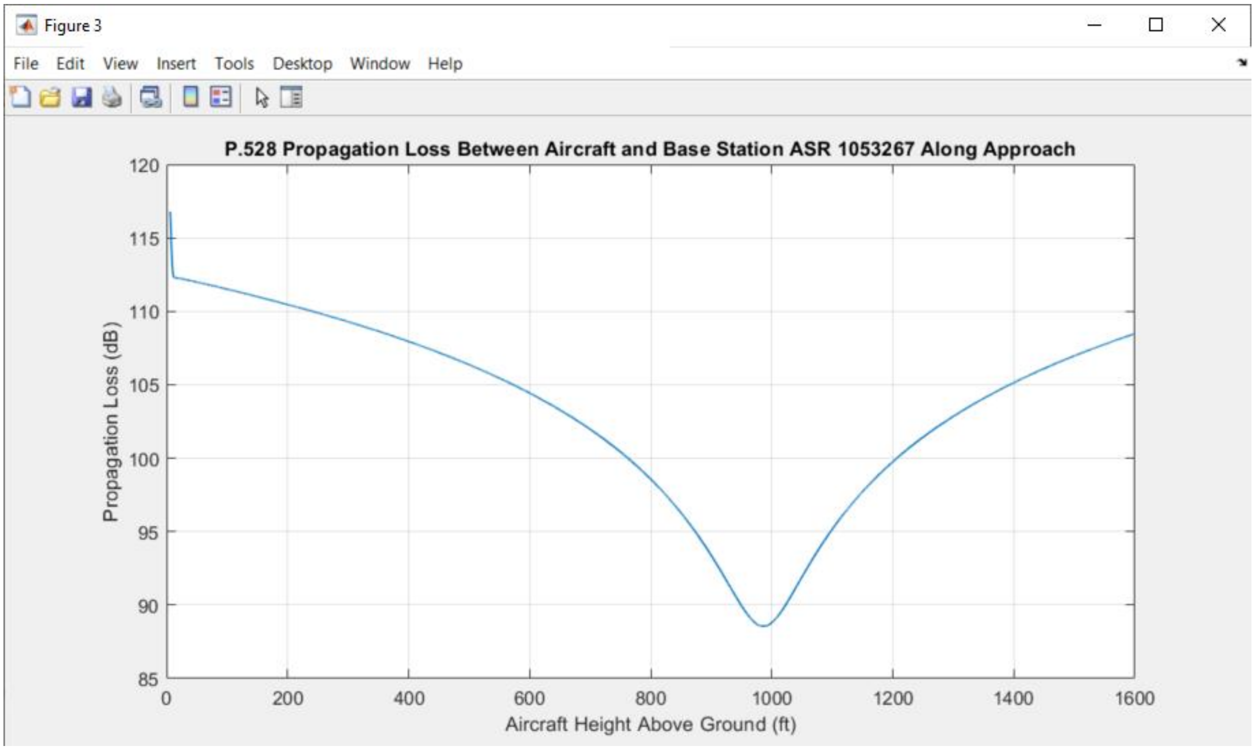


Note that with these alternative vertical scan angle assumptions, the grating lobe is no longer present (which in Figure 10-33 causes the peak interference levels). However, the possibility of the main beam being scanned up to the horizon can lead to much more prolonged interference near the peak levels (as seen in Figure D-16).

Propagation Loss

As described in Section 6.3.1 of the report, the propagation loss is computed using the Recommendation ITU-R P.528-4 propagation model, using a 1% time availability parameter. The center frequencies of the first, third, and fifth base stations encountered along the approach (ASR 1280620, ASR 1053267, and ASR 1256593) were assumed to be 3850 MHz, and the center frequencies of the second and fourth base stations encountered along the approach (ASR 1058071 and ASR 1209185) were assumed to be 3750 MHz. The only other input parameters to the propagation model are the base station heights above ground (provided in Table 8-2), the aircraft height above ground (which varies along the approach according to the approach path described in Section 8.1.3), and the horizontal distance between the aircraft and each base station (which varies along the approach and is computed geometrically based on the relative position between the aircraft and each base station).

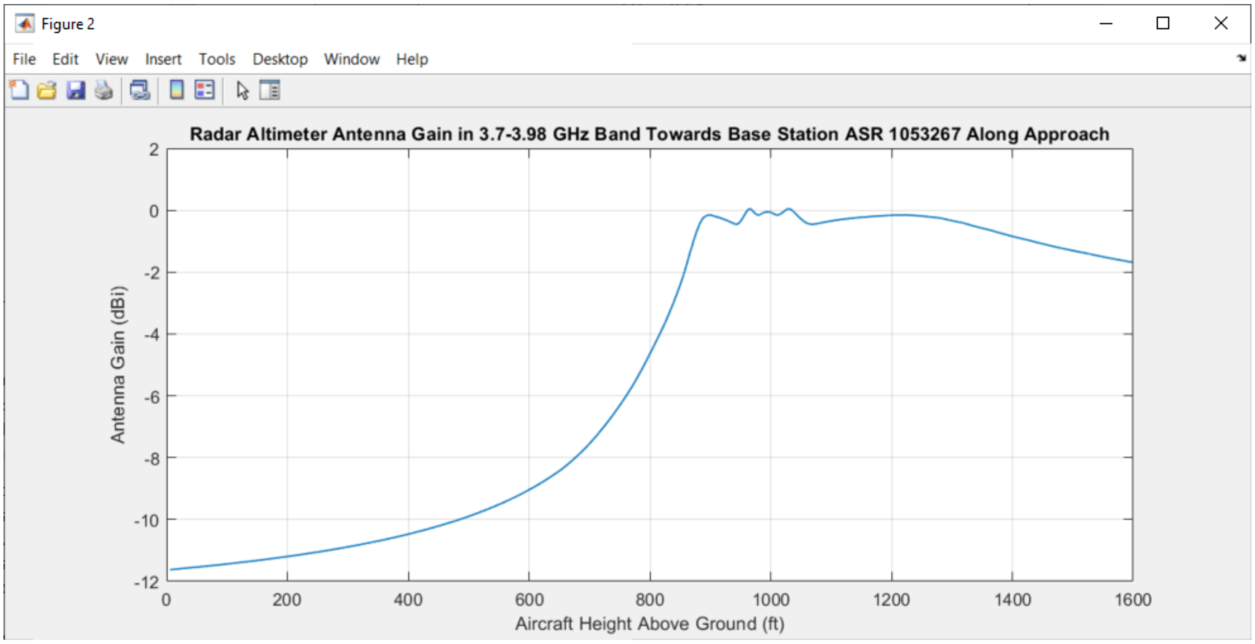
As an example, the following plot shows the computed propagation loss between the aircraft and the base station ASR 1053267 using the P.528 model throughout the full approach.



Radar Altimeter Antenna Gain

The radar altimeter antenna pattern is assumed to be that shown in Figure 6-11. This is based on measured pattern data taken at 3850 MHz, as described in Section 6.3.4.1. This pattern is assumed to be rotationally symmetric about the boresight axis. During the entire approach, the aircraft is assumed to have a nose-up pitch attitude of 5 degrees. The altimeter antenna gain in the direction of each base station must be computed accounting for this pitch angle relative to the local horizontal.

As an example, the following plot shows the computed radar altimeter antenna gain directed towards the base station ASR 1053267 throughout the full approach.



RX Cable Loss

The receive path RF cable loss in the aircraft is assumed to be 3 dB. This is the insertion loss between the altimeter receiver antenna output and the receiver input on the altimeter transceiver.

This assumption corresponds to 6 dB of total cable loss in the aircraft installation (3 dB in the transmit path, and 3 dB in the receive path), which is the same assumption that was made in determining the loop losses for the AVSI testing of interference tolerance thresholds. This was taken as a reasonable worst-case assumption for altimeter installations across a wide variety of aircraft types, accounting as well for the allowable cable loss ranges specified by the altimeter manufacturers in their installation manuals. The actual cable losses on small general aviation aircraft and helicopters may sometimes be less than this, while the losses on large transport aircraft may sometimes be higher. However, the vast majority of installations will have somewhere between 3 and 9 dB of total cable loss (1.5-4.5 dB in the receive path), so deviations from the 6 dB total (3 dB receive) assumption will rarely be significant.