

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of	)	
World Radiocommunication Conference	)	OIA Docket No. 24-30
Advisory Committee	)	

**COMMENTS OF AEROSPACE AND FLIGHT TEST
RADIO COORDINATING COUNCIL, INC.**

Jonathan Westerling
Acting President
PO Box 780481
Wichita, KS 67278

October 12, 2026

TABLE OF CONTENTS

	Page
I. SUMMARY	2
II. INTRODUCTION	4
III. AMT IS A WELL-RECOGNIZED SAFETY-OF-LIFE APPLICATION.....	7
IV. AMT CONDUCTED IN 1435-1525 MHz AND 2360-2395 MHz HAVE PRIORITY OVER OTHER MOBILE SERVICES UNDER ITU-R RADIO REGULATIONS, AND DC-MSS-IMT MUST PROTECT AMT IN THESE FREQUENCY BANDS GIVEN ITS COMPLEMENTARY STATUS	10
V. U.S. STUDIES SUBMITTED TO WORKING PARTY 4C MAKE PLAIN THE DC-MSS-IMT WOULD BE A SERIOUS INTERFERENCE THREAT TO AMT OPERATIONS ON A CO-CHANNEL, OR IN-BAND, BASIS	10
VI. THE UNITED STATES POSITION SHOULD BE NO CHANGE IN THE FREQUENCY BANDS USED FOR AMT IN REGION 2.....	13
VII. FLIGHT TEST AMT OPERATIONS MUST BE PROTECTED BY AN ADEQUATE PFD LIMIT APPLICABLE TO ANY ADJACENT BAND DC- MSS-IMT OPERATIONS	15
VIII. THE PROPOSED ADJACENT CHANNEL PFD LIMIT IN VIEW B IS INADEQUATE TO PROTECT AMT.....	17
IX. ALTERNATIVE CRITERIA TO PROTECT AMT BASED ON I/N AND PERCENTAGE-OF-TIME WOULD BE DECIDEDLY INFERIOR TO A PFD LIMIT	21
X. CONCLUSION.....	22
 APPENDIX A AFTRCC Members	
 APPENDIX B Aerospace Corp. Study Deriving PFD Limits to Protect AMT Against Interference from DC-MSS-IMT	
 APPENDIX C Proposed Addition to View A Draft New Resolution	

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of	)	
World Radiocommunication Conference	)	OIA Docket No. 24-30
Advisory Committee	)	

**COMMENTS OF AEROSPACE AND FLIGHT TEST
RADIO COORDINATING COUNCIL, INC.**

Aerospace and Flight Test Radio Coordinating Council, Inc. ("AFTRCC"), hereby submits its Comments on the Public Notice of the Office of International Affairs seeking comment on certain draft recommendations the Commission received from the World Radiocommunication Conference Advisory Committee ("WAC") in the above-captioned proceeding and certain draft proposals the Commission received from the National Telecommunications and Information Administration ("NTIA").¹ AFTRCC limits its comments to one Agenda Item ("AI"), AI 1.13 of the 2027 World Radiocommunication Conference ("WRC-27"). Under AI 1.13, the International Telecommunication Union ("ITU") is "consider[ing] studies on possible new allocations to the mobile-satellite service for direct connectivity between space stations and International Mobile Telecommunications (IMT) user equipment to complement terrestrial IMT network coverage" (such direct connectivity referred to herein as "DC-MSS-IMT").²

¹ *Office of International Affairs Seeks Comment on Recommendations Approved by the World Radiocommunication Conference Advisory Committee*, Public Notice, OIA Docket No. 24-30, DA 26-1052, rel. Sep 29, 2026 ("Notice"). The WAC draft recommendations for AI 1.13, including competing views because consensus was not reached, are contained in Attachment A of the Notice. The NTIA draft proposal for AI 1.13 is contained in Attachment B of the Notice.

² Notice, Att. A, at 143 of 240. Three competing views on AI 1.13 were submitted to the Commission by the WAC. *See* Notice, Att. A, at 141-196 of 240. The NTIA draft proposal is found in Notice, Att. B, at 207-226 of 240.

AI 1.13 is considering several bands between 694 to 2690 MHz, inclusive, for possible new allocations to the mobile satellite service (“MSS”) for DC-MSS-IMT connectivity complementary to IMT, a mobile service application. It has been said that “Agenda Item (AI) 1.13 is of critical importance to the United States.”³ AFTRCC agrees. Not only is there a significant opportunity to identify spectrum that could be allocated in the International Table of Frequency Allocations for DC-MSS-IMT operations, but it is also equally important that this is done in a balanced manner that recognizes and protects incumbent spectrum users. For example, several of the frequency bands being considered either overlap or are adjacent to shared allocations heavily used in the United States for critical incumbent primary Federal and non-Federal aeronautical mobile telemetry (“AMT”) operations – 1435-1525 MHz band and 2360-2395 MHz band – which prior actions at World Radiocommunications Conferences establish have priority over other mobile services in these same bands.

AFTRCC respectfully submits that primary incumbent AMT operations in the United States must be protected in the U.S. position concerning AI 1.13.⁴

I. SUMMARY

AFTRCC respectfully submits that any U.S. positions regarding AI 1.13 in connection are balanced to ensure that any MSS allocations to enable DC-MSS-IMT complementary to the IMT application of the mobile service do not undermine AMT operation. Multiple U.S. studies that have been contributed to Working Party 4C demonstrate that DC-MSS-IMT will cause co-

³ Comments of SpaceX, OIA Docket No. 24-30, at 1 (Oct. 6, 2026).

⁴ AFTRCC understands that there are Federal AMT operations in a Federal mobile service allocation that includes 1780-1850 MHz. Although there are no non-Federal AMT operations in this band, AFTRCC defers the treatment of this band to the NTIA proposal, which calls for No Change or, in the alternative, an adequate PFD limit to protect AMT (and other services which use the band).

channel cross-border interference to AMT. Compromising the mission critical use of the AMT frequency bands through in-band allocations to MSS for DC-MSS-IMT would be a poor outcome for the United States. Further, if MSS allocations are to be considered in frequencies adjacent to AMT allocations, provisions should be adopted in the Resolution to resolve AI 1.13 to ensure protection of AMT from harmful interference caused by DC-MSS-IMT.

In particular, AFTRCC respectfully urges the United States, for Region 2, to adopt for 1.13 a No Change position for the 1435-1525 MHz and 2360-2395 MHz bands given studies showing in-band harmful interference to AMT from DC-MSS-IMT system. A No Change position for Region 2 in these bands would be consistent with the NTIA draft proposal and View A, which AFTRCC supports in this regard.

AFTRCC is not opposed to an MSS allocation in Region 2 in the space-to-Earth direction in the 2345-2360 MHz band as advocated by AT&T *et al.* in View A *provided that* a PFD limit is adopted that is adequate to protect flight test AMT operations consistent with the M.1459 protection criteria. Specifically, based on the appended study prepared by Aerospace Corporation for the AMT community, the U.S. should include a PFD limit of -183.5 dB(W/(m²·4kHz)) (or -159.5 dB(W/(m²·4kHz))) in the resolution applicable from 20° through 90° angle of arrival, inclusive. View B, including the proposed adjacent band PFD limit of -144 dB(W/(m²·4kHz)) (or -120 dB(W/(m²·4kHz))), should be rejected because U.S. studies submitted to Working Party 4C demonstrate that this PFD limit would be insufficient to protect AMT operations supporting flight tests consistent with safety-of-life. View C should also be rejected with regard to spectrum adjacent to the AMT bands discussed herein to the extent inconsistent with the positions AFTRCC takes herein.

II. INTRODUCTION

AFTRCC is a member organization of the nation's principal aerospace manufacturers. *See Appendix A* attached hereto for a list of AFTRCC's current Members and Associate Members. AFTRCC was founded in 1954 to serve as an advocate for the aerospace industry on matters affecting spectrum policy, particularly with regard to access to adequate and reliable AMT spectrum for flight test operators to conduct safe and productive flight tests of both military and civil aircraft within the United States, including advanced uncrewed aircraft systems (“UAS” often referred to as “drones”) and vertical take-off and landing (“VTOL”) aircraft. AFTRCC works in close collaboration with Government Area Frequency Coordinators (“AFCs”), who are responsible for coordinating Department of Defense (“DoD”) use of Federal and shared AMT spectrum. This collaboration between AFTRCC and the AFCs helps ensure, among other things, that receipt of interference-free real-time telemetry data during flight test operations are protected, aeronautical mobile communications during flight testing is enhanced, and flight safety and the productivity of test flight activity is maximized.⁵

Access to interference-free spectrum that supports reliable, real-time mobile telemetry by ground operators from aircraft during flight tests conducted by American aerospace and defense (“A&D”) manufacturers is in the critical path for the success of the United States' military and its civil aviation industry (both passenger and cargo aircraft, both crewed and uncrewed) and maintaining an edge over our country's international rivals.⁶ To provide an illustration of the

⁵ More information regarding AFTRCC may be found at <https://aftfcc.org>.

⁶ The A&D industry is vital to the national economy. In 2025 data compiled by the Aerospace Industries Association (“AIA”), the industry supported over 2.1 million U.S. jobs (434,000 direct jobs in the Aeronautics/Aircraft sector), with average labor income per A&D job in excess of \$127,000 (40% above the national average) and generated over \$988 billion in total sales. In terms of economic value, the industry contributed 1.6 percent of total nominal GDP and a \$109.2 billion trade surplus, the largest positive trade balance of any U.S. manufacturing sector. See AIA, 2026 Facts & Figures (June 25, 2026), at <https://www.aia->

range of systems relying on flight testing, here is *a sampling* of military, UAS, VTOL, and commercial passenger aircraft platforms dependent on flight testing:

- Bell MV-75 Cheyenne Long Range Assault Aircraft
- Bell AH-1Z Viper Attack Helicopter
- Bell UH-1Y Venom Marine Corps Helicopter
- Bell DARPA SPRINT X-76 ((High-Speed Vertical Takeoff and Landing (HSVTOL) technology)
- Bell Boeing V-22 Osprey military multi-mission tiltrotor aircraft
- Boeing T-7A Red Hawk (USAF Trainer Aircraft)
- Boeing F-47 (6th generation fighter)
- Boeing F/A-XX (Navy sixth-generation carrier-based strike fighter)
- Boeing E-7 Wedgetail Airborne Early Warning and Control
- Boeing B-52 Stratofortress
- Boeing F-15 Strike Eagle Tactical Fighter Jets
- Boeing AH-6 Apache
- Boeing MH-139 Medium-Lift Military Helicopter
- Lockheed Martin F-35 Lightning 2
- Lockheed Martin F-16 Fighting Falcon
- Northrop Grumman B-21 Raider long-range strategic stealth bomber
- Northrop Grumman E-2D Advanced Hawkeye, Navy Airborne Command and Control surveillance platform
- Sikorsky VH-92A Patriot (e.g., helicopter transports for President and Vice President)
- Textron Aviation Defense T-6 Texan II (advanced military flight training)
- Textron AT-6 Wolverine (light attack, counter-insurgency (COIN), and ISR)
- Northrop Grumman AGM-88G Advanced Anti-Radiation Guided Missile Extended Range
- AIM-9 Sidewinder missile programs
- JDAM aviation program retrofits (all-weather, precision-guided munitions)
- AeroStar UAS government classified programs
- Boeing MQ-25 Stingray (Navy's Carrier-Based UAS refueler)
- Northrop Grumman YFQ-48A Talon Blue (next-generation uncrewed autonomous aircraft designed to support crewed fighters)
- Sikorsky Nomad rotor-blown wing VTOL drone
- Joby J208 Autonomous Caravan
- Joby S4 electric vertical-take-off-and landing (eVTOL) Air Taxis
- Beechcraft utility single- and twin-engine aircraft including King Air 360, King Air 260, King Air 90, Denali 220, Baron G58, and Bonanza G36
- Bell Helicopter 525 Relentless super-medium twin-engine helicopter
- Boeing 777, 787/F, 747-8, KC-46, 737 MAX, 777-8F/-9 passenger aircraft

aerospace.org/news/2026-aia-facts-figures-u-s-aerospace-defense-industry-leads-the-world-with-1-trillion-in-sale/

- Cessna 408 Sky Courier, 208 Caravan, 206 Stationair, 182 Skylane, and 172 Skyhawk
- Challenger 350 Mid-Size Business Jet
- Gulfstream Aerospace's modern large-cabin and ultra-long-range business jet lineup (G400, G500, G600, G650, G700, and G800)
- G7500, G8000, and G6500 Business Jets
- Textron mid-size business jets (Citation 700 Longitude, 680A Latitude, Ascend, XLS+)
- Textron light-weight business jets (525C CJ4, 525B CJ3, and 525 M2)
- Numerous classified or proprietary programs that cannot be identified here; these include military aircraft, UAS, missiles, other airborne weapons, and commercial aircraft.

As this list of programs relying on interference-free spectrum access to conduct AMT operations makes clear, AMT advances the national priorities of military superiority, safe and efficient aviation for pilots, crews, and passengers, and the achievement of Drone Dominance.⁷

As the Federal Aviation Administration (“FAA”) succinctly explained in its 2016 Report to Congress on AMT testing and spectrum needs,

[d]isplaying and analyzing [AMT] data in real-time allows flight testers to monitor critical parameters and mitigate risks in order to conduct safe, effective, and efficient missions. U.S. aerospace companies depend heavily on AMT services to reduce both risks and costs. Although AMT is not well known inasmuch as it serves a specialized technical purpose typically not seen by the general population, it is an important enabler for the aerospace industry. Indeed, AMT is in the critical path for U.S. aerospace manufacturers in delivering new products, and is a key asset to aerospace research and development (R&D), test and evaluation, and certification by the FAA.⁸

⁷ E.O. 14307, Unleashing American Drone Dominance, (June 6, 2025). The E.O. stresses the need to “accelerate testing and to enable routine drone operations, scale up domestic production, and expand the export of trusted, American-manufactured drone technologies to global markets”—all activities that rely on flight testing. *See id.* ¶ 1. The E.O. requires the Secretary of Transportation to ensure “FAA UAS Test Ranges are fully utilized to support the development, testing, and scaling of American drone technologies, with a focus on BVLOS operations, increasingly autonomous operations, advanced air mobility, and other advanced operation.” *See id.* ¶ 5(b). In addition to activities on FAA Ranges, analogous and critical activities advancing drone technologies and platforms take place on many A&D manufacturers’ facilities today, as well as DoW ranges, on an increasing scale reliant on spectrum in the AMT Bands.

⁸ *See* Letters of Michael P. Huerta, Administrator, FAA, to Sen. John Thune, Chairman, Committee on Commerce, Science, and Transportation United States Senate *et al.* (April 29, 2016) (“FAA Thune Letter”) attaching Mitre Corp., Report to Congress on Aeronautical Mobile

In the United States, the 1435-1525 MHz and 2360-2395 MHz bands are primary Federal/non-Federal shared allocations and are the workhorse frequency bands supporting AMT during flight testing conducted by both Federal and non-Federal operators.⁹ As such, the United States should work toward WRC-27 outcomes that protect vital AMT operations from cross-border interference.

III. AMT IS A WELL-RECOGNIZED SAFETY-OF-LIFE APPLICATION

It is noteworthy in considering how to resolve AI 1.13 that the ITU-R, the FAA, the Commission, and NTIA consider AMT a safety-of-life application. Accordingly, AFTRCC urges the United States to take this additional factor into account when formulating its position on AI 1.13 with respect to spectrum bands that are utilized by AMT flight test operators.

Recommendation ITU-R M.1459, which establishes the recognized protection criteria for AMT in the 1435-1525 MHz band and the 2360-2395 MHz band, acknowledges that “[a]eronautical telemetry and telecommand operations are used for flight testing of manned and unmanned aerospace vehicles. Vehicles are tested to their design limits, thus making safety of flight dependent on the reliability of information received on a real-time basis.”¹⁰ In its 2016 Report to Congress, the FAA elaborated that “[e]ven seemingly routine [flight] tests can involve

Telemetry (July 2016) (“FAA Report to Congress”) found at <https://www.faa.gov/sites/faa.gov/files/2021-11/Report-to-Congress-on-Aeronautical-Mobile-Telemetry.pdf> The FAA Report to Congress was required by the FAA Modernization and Reform Act of 2012, Section 820, which requested the FAA report to Congress on the AMT needs of civil aviation and the potential impacts from introducing new in-band radio services into AMT spectrum. *See* FAA Thune Letter at 1.

⁹ *See* 47 C.F.R. § 2.106 (U.S. Table of Frequency Allocations).

¹⁰ Rec. ITU-R M.1459, Protection criteria for telemetry systems in the aeronautical mobile service and mitigation techniques to facilitate sharing with geostationary broadcasting-satellite and mobile-satellite services in the frequency bands 1 452-1 525 MHz and 2 310-2 360 MHz, Annex 1, § 2.1 (05/2000).

significant risk to safety of life.”¹¹ The FAA explained, access to real-time telemetry data during flight tests “is crucial to monitor hazardous trends exceeding aircraft limitations, and to safely and incrementally progress to higher risk flight test points.”¹² The safety-related nature of AMT should guide the United States in its development of its position on AI 1.13 in connection with spectrum in or adjacent to the AMT bands relied upon by the American A&D industry and DoW to advance important national objectives.

Notably, the Commission has for decades taken pains to protect the AMT bands, and specifically flight testing, from risks of harmful interference, regularly citing the safety-related nature of AMT operations during flight testing. For example, in 1989 the Commission determined that the telemetry bands should be classified as “Restricted” and thus protected from fundamental emissions of unlicensed devices. The agency stressed that the telemetry bands at 1435-1525 MHz and 2360-2395 MHz “involv[e] safety-of-life.”¹³ Likewise, in 1990 the Commission concluded that secondary use of flight test frequencies for air shows could result in significant harmful interference “impair[ing] the efficiency and safety of the flight test industry.”¹⁴ When the Commission adopted rules in 2012 to permit low-powered wireless

¹¹ FAA Report to Congress at 5.

¹² *Id.* at 2 (citing F.N. Stoliker (editor), “Introduction to Flight Test Engineering,” North Atlantic Treaty Organisation, Research and Technology Organisation, Flight Test Techniques Series, vol. 14, July 2005).

¹³ *In the Matter of Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License*, First Report and Order, 4 FCC Rcd 3493, 3502 (1989); *see also* 47 C.F.R. § 15.205(a).

¹⁴ *In the Matter of Petition to Amend Part 87 of the Commission's Rules to Allot VHF Aeronautical Frequencies for the Coordination of Air Show Events*, Order, 5 FCC Rcd 4641, 4642 (1990). The Commission added “In short, sharing of [AMT] frequencies with unlike services is difficult at best because schedules of telemetry flight tests are unpredictable and delays costly. Further, interference cannot be tolerated. For example, in the event of a crash the telemetry data may be the only means available to determine the cause of the crash. In this case, interference to the telemetry transmission could be disastrous.” *Id.* quoting Report and Order, GEN Docket 89-16, 5 FCC Rcd 493 (1990).

Medical Body Area Networks (“MBANS”) in 2360-2400 MHz, it imposed restrictions on where MBANS could be used and imposed a requirement to for the MBANs coordinator to collaborate with AFTRCC “to protect AMT receive sites.”¹⁵ More recently, the agency adopted “safeguards [applicable to licensed, secondary wireless microphones in the L-band] designed to protect AMT,” due to safety considerations of the primary AMT operations.¹⁶

The NTIA also recognizes the safety-of-life nature of AMT in the AMT Bands. Referring to the 1435-1525 MHz Band, it has explained that “AMT systems are used for flight testing of manned and unmanned aerospace vehicles. Vehicles are tested to their design limits, thus making safety of flight dependent on the reliability of information received on a real-time basis.”¹⁷ NTIA recognizes the similar real-time data applications during flight testing in the 2360-2395 MHz band.¹⁸

For these reasons, it is critical that the protection of AMT use for flight testing extend to each test flight rather than all flight-testing activity in the aggregate. Otherwise, the safety of flight tests will be compromised.

¹⁵ *In the Matter of Amendment of the Commission's Rules to Provide Spectrum for the Operation of Medical Body Area Networks*, First Report and Order and Further Notice of Proposed Rulemaking, FCC 12-54, 27 FCC Rcd 6422 ¶ 59 (2012) (“MBANS Order”).

¹⁶ *In the Matter of Promoting Spectrum Access for Wireless Microphone Operations et al.*, Report and Order, 30 FCC Rcd 8739, 8780, ¶106 (2015) (“Wireless Microphones Order”).

¹⁷ NTIA, Federal Government Spectrum Use Reports 225 MHz – 7.125 GHz, 1435-1525 MHz, at 1, found at https://www.ntia.gov/files/ntia/publications/compendium/1435.00-1525.00_01MAY15.pdf.

¹⁸ NTIA, Federal Government Spectrum Use Reports 225 MHz – 7.125 GHz, 2360-2390 MHz, at 3, found at https://www.ntia.gov/files/ntia/publications/compendium/2360.00-2390.00_01DEC15.pdf (“The Air Force uses this band to support developmental and operational tests of military flight systems. The AMT systems are used to transfer real-time data to multiple receive locations while the flight system is either on the ground or during airborne testing.”).

IV. AMT CONDUCTED IN 1435-1525 MHZ AND 2360-2395 MHZ HAVE PRIORITY OVER OTHER MOBILE SERVICES UNDER ITU-R RADIO REGULATIONS, AND DC-MSS-IMT MUST PROTECT AMT IN THESE FREQUENCY BANDS GIVEN ITS COMPLEMENTARY STATUS

The 1435-1525 MHz band and 2360-2395 MHz band are identified as AMT bands in the International Table of Frequency Allocations and ITU-R Radio Regulations and are afforded priority over other mobile services in the Region 2 and the United States, respectively. This is a result, at least in part, because AMT operations, as noted in the previous section, are safety-of-life applications within the aeronautical mobile service. ITU-R Radio Regulation No. 5.343 provides that “[i]n Region 2, the use of the band 1435-1535 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile service.”¹⁹ Similarly, Radio Regulation No. 5.394 states that “[i]n the United States, the use of the band 2300-2390 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile services.”²⁰ Given that DC-MSS-IMT, by definition, is to be complementary to the mobile service application of IMT, AFTRCC submits that the conclusion follows from these footnotes to the Table of Allocations that AMT would have priority not only over other mobile services in these two bands, but that it would have priority over, and be entitled to protection from, DC-MSS-IMT.

V. U.S. STUDIES SUBMITTED TO WORKING PARTY 4C MAKE PLAIN THE DC-MSS-IMT WOULD BE A SERIOUS INTERFERENCE THREAT TO AMT OPERATIONS ON A CO-CHANNEL, OR IN-BAND, BASIS

The United States has submitted to ITU-R WP4C a study, Document 4C/692, which examines the compatibility with AMT operations of three DC-MSS-IMT NGSO systems whose

¹⁹ 47 C.F.R. § 2.106(b)(343).

²⁰ *Id.* § 2.106(b)(394).

characteristics were submitted to the Working Party. This study utilized the MSS system characteristics provided, and for each frequency band, NGSO system, and location (northern and southern U.S. border) simulated thousands of randomly initiated two-hour simulations of flight tests and simultaneous continuous simulation of the NGSO systems. The study results demonstrate that, when DC-MSS-IMT operates *on a co-channel basis* with AMT, separation distances of almost 45 miles (71+ km) up to approximately 420 miles (up to 675 km) between mobile user equipment in countries neighboring the United States seeking downlink connectivity with NGSO DC-MSS-IMT satellites and cross-border AMT receive stations in the United States are required to protect AMT.²¹ The necessary separation distance depends on the operating parameters of the NGSO system and whether the northern and southern country border is involved.²² These study results are based upon the well-established protection criteria of Rec. ITU-R M.1459 of $I/N \leq -4.15$ dB for 99.5% or more of the time, and the results cited above are predicated on the protection of every flight test, given the dependence of safety-of-life on the real time receipt of telemetry data, as described above.²³

²¹ See Document 4C/692. An earlier U.S. study contributed to ITU-R WP4C also showed the need for significant separation distances between user equipment being served and AMT receive sites to ensure cross-border compatibility, examining three DC-MSS-IMT systems whose characteristics were submitted to ITU-R WP4C. See Document 4C/504. Document 4C/692 further develops the analysis presented in Document 4C/504.

²² See *id.*, Attachments 1-3, Table 5 and *id.* Attachments 4-6, Table 4. In the case of one system, the separation distances in the co-channel case would be 44.38 to 47.5 miles (71 and 76 km) at the Northern Border and 82.5 miles (132 km) at the Northern Border. See *id.* For the other system studied (more specifically, two variations of the same System), at locations on the southern border, the required separation distances range from 356.25 miles (570 km) to 421.88 miles (675 km). See, *id.*, Attachments 1-3, Table 5.

²³ SpaceX, in its October 6 Comments, contends that existing protection criteria developed to protect incumbent through ITU-R processes are categorically “outdated and overly conservative,” contending that “[n]o matter how efficient the studies’ underlying assumptions, those criteria will produce inefficient outcomes and overly constrain U.S. DC-MSS-IMT systems.” SpaceX not only fails to cite authority for these conclusory statements, but it also offers no documentary or study support for these assertions. In any event, any road to revisit ITU-R criteria at issue in AI 1.13 to protect incumbent services is not through this agenda item, or even through Working Party 4C, but through the appropriate processes after WC-27 and before the proper ITU-

The need for the separation distances found in to ensure the M.1459 protection criteria are satisfied is significant in terms of the number of Federal and AMT Federal AMT sites that would be protected. According to the AMT site database maintained by AFTRCC of both Federal and non-Federal AMT sites, there are at least 380 AMT sites in the continental United States within 400 miles of the territory of neighboring and nearby countries (Canada, Mexico, Cuba, and/or the Bahamas). There are 297, 205, and 82 AMT sites, respectively within 300, 200, and 100 miles of the territory of neighboring countries. Thus, the inescapable conclusion of the studies is that DC-MSS-IMT systems, if authorized in-band in neighboring countries, would present a serious threat of co-channel cross-border interference to AMT operations absent adequate mitigation measures. To corroborate these results, the latest U.S. contribution to ITU-R WP4C found that, at an AMT location 163 km south of the 49th parallel, *in-band* DC-MSS-IMT operations would cause cross-border interference exceeding the Rec. ITU-R M.1459 AMT protection criteria.²⁴ This later study, 4C/692, indicated that the protection criteria would not be satisfied even when the NGSO operator employed mitigation measures identified in the study such as power tapering, satellite selection rules that would prevent DC-MSS-IMT satellite transmissions to user equipment north of the border while the satellites are over the U.S. territory, and a loading factor typically far below the submitted characteristics to WP4C was assumed. With reference to the distance of the AMT site considered from the border, the study

R Working Party, e.g., WP5B in the case of aeronautical mobile services, such as AMT. There was no effort to do so during the WRC-27 preparation cycle and, in fact, WP5B reiterated four times that Rec. ITU-R M.1459 provides appropriate protection criteria for AMT, most recently in 4C/360.

²⁴ Document 4C/848, Table 2, p. 9 (conducting study at an AMT Receiver Location of 47.5369°N, 122.3039°W, at Boeing Airfield in the southernmost part of Seattle.)

repeatedly iterates that “[r]esults for . . . AMT locations closer to the border would require further study.”²⁵

VI. THE UNITED STATES POSITION SHOULD BE NO CHANGE IN THE FREQUENCY BANDS USED FOR AMT IN REGION 2

For AI 1.13, within Region 2, AFTRCC supports the NTIA draft proposal and View A for the U.S. position submitted by AT&T, CTIA, GSMA, T-Mobile, and Verizon (“AT&T *et al.*”). Each of these excludes an MSS allocation in or overlapping the 1435-1525 MHz band and the 2360-2395 MHz band.

NTIA calls for No Change to protect safety-of-life AMT systems in the 1475-1518 MHz band (satellite downlinks for DC-MSS-IMT systems) and the 2300-2400 MHz band.²⁶ Specifically, NTIA explains that the “1 435-1 525 MHz . . . band supports flight testing and is used to test and certify commercial aircraft in the Americas for aeronautical mobile telemetry or (AMT), and studies show certification and testing operations will experience harmful interference from DC-MSS-IMT in co-frequency operations,” and concludes that “Analysis supports a No Change (NOC) position for the protection of aviation safety-of-life systems in the 1 475-1 518 MHz band.”²⁷ Regarding AMT operations in the 2360-2395 MHz band, NTIA notes that “Studies show that AMT services will experience harmful interference from DC-MSS-IMT in co-frequency operations. In order to protect these services, a PFD limit is needed,” and

²⁵ See Document 4C/848 at pp. 16, 21, 26, 31, 36, and 41 (discussing in-band and adjacent band results in the 1435-1525 MHz, 1780-1850 MHz, and 2360-2395 MHz AMT Bands).

²⁶ See Notice, Att. B, at 216-224 of 240. Specifically, NTIA explains that the “1 435-1 525 MHz . . . band supports flight testing and is used to test and certify commercial aircraft in the Americas for aeronautical mobile telemetry or (AMT), and studies show certification and testing operations will experience harmful interference from DC-MSS-IMT in co-frequency operations,” and concludes that “Analysis supports a No Change (NOC) position for the protection of aviation safety-of-life systems in the 1 475-1 518 MHz band.”

²⁷ Notice, Att. B, at 207-208 and 216 of 240.

concludes that “[a]nalysis supports a No Change (NOC) position for the protection of aviation safety-of-life systems in the 2 300 – 2 400 MHz band.”²⁸

View A advances similar outcomes in terms of a draft United States position. In the bands 1427-1475 and 1475-1518 MHz, AT&T *et al.*, promote an MSS allocation for DC-MSS-IMT solely in Regions 1 and 3 (and on a secondary basis).²⁹ Similarly, in View A an MSS allocation for DC-MSS-IMT is excluded from the 2360-2395 MHz band.³⁰ AFTRCC supports, for Region 2, the View A outcomes for the 1435-1525 MHz and 2360-2395 MHz bands, and finds them consistent with the NTIA draft proposal.³¹

A primary allocation to MSS with respect to AMT in any of the bands under consideration would be contrary to Resolution No. 253 (WRC-23) and threaten the critical use of the bands 1435-1525 MHz and 2360-2395 MHz for flight testing. The *further resolves 1* and 2 in Resolution 253 leave no doubt incumbent services are to be protected and through technical

²⁸ Notice, Att. B, 208, 223 of 240. Regarding the 1780-1850 MHz band, which AFTRCC understands is used by Federal AMT operators, NTIA found that “[s]tudies show Fixed Service (FS), Aeronautical Mobile Service (AMS), and AMT services will experience harmful interference from DC-MSS-IMT in co-frequency operations. In order to protect these services, a PFD limit is needed” but that “the studies have not yet reached consensus on the protection levels needed for incumbent operations” in this (and other) nearby frequency ranges under consideration under AI 1.13. Notice, Att. B, at 207, 221 of 240.

²⁹ See Notice, Att. A, at 144, 155, 156 of 240 (draft footnotes 5.D113 and 5.H113 excluding Region 2 from proposed MSS allocations in 1427-1518).

³⁰ See Notice, Att. A, at 145, 155-156 of 240 (draft footnote 5.G113 provides, for Region 2, a secondary MSS allocation in the space-to-Earth direction for DC-MSS-IMT limited to 235-2360 MHz).

³¹ AFTRCC observes that View A would allow for an MSS allocation for DC-MSS-IMT in the space-to-Earth direction in parts of the 1780-1850 MHz band, specifically 1805-1850 MHz in Region 2. See Notice, Att. A, at 144 of 240. In the United States, as noted earlier, 1780-1850 MHz is used by Federal AMT operators for flight testing, among other Federal applications, and NTIA, in its draft proposal for AI 1.13 explains that a PFD limit is needed to protect AMT. See Notice, Att. B at 221 of 240. The study appended hereto provides a PFD limit protective of AMT for this band which the United States should propose if the U.S. position is not No Change for 1780-1850 MHz. See Aerospace Corp., Proposed Power Flux Density Limits to Protect Aeronautical Mobile Telemetry Receiving Stations in the Frequency Bands 1 435-1 525 MHz, 1 780-1 850 MHz, and 2 360-2 395 MHz from Emissions of Non-GSO DC-MSS-IMT Systems, at 17-18 (Oct. 12, 2026) (“Aerospace Corp. Study”) *appended hereto as Appendix B*.

and operational measures DC-MSS-IMT are to be conducted on a secondary, non-interference basis to mobile services, including AMT:

further resolves

1 to conduct studies on sharing and compatibility between incumbent services, including in adjacent frequency bands, ensuring the protection of incumbent services in accordance with the Radio Regulations;

2 to study possible technical and operational measures to ensure that the stations in the MSS do not cause harmful interference to, or claim protection from, stations operating in the mobile service.

VII. FLIGHT TEST AMT OPERATIONS MUST BE PROTECTED BY AN ADEQUATE PFD LIMIT APPLICABLE TO ANY ADJACENT BAND DC-MSS-IMT OPERATIONS

AFTRCC is not opposed to a secondary MSS allocation in the space-to-Earth direction in the 2345-2360 MHz band in Region 2 as advocated by AT&T *et al.* in View A provided that a PFD limit is adopted that is adequate to protect flight test AMT operations consistent with the M.1459 protection criteria. The U.S. contribution Document No. 4C/692 found that, depending on the characteristics of NGSO MSS systems operating in the 2245-2360 MHz band supporting DC-MSS-IMT, significant separation distances could be required to protect AMT.

The study appended hereto, prepared by Aerospace Corp. for the AMT community, derives a PFD limit to protect AMT operations consistent with Rec. ITU-R M.1459 by analyzing the operational and technical characteristics of multiple DC-MSS-IMT systems submitted to Working Party 4C.³² In that study, the PFD limit is derived with the recognition that real-time receipt of telemetry data is critical not only for the efficiency of the flight test activity but also for the purpose of ensuring the safety of the pilot, the crew, and any persons on the ground in

³² See Appendix B, Aerospace Corp. Study, §2.2, at 6-10. See also results discussed in *id.*, § 3, at 14-18.

addition to the test aircraft itself, which is recognized by Rec. ITU-R M.1459 and several other ITU-R Reports, e.g., Rpts ITU-R M.2286 and 2324. Accordingly, the PFD limit should be derived to ensure that *all* flight tests are protected. The Aerospace Corp. Study does so with a 99% confidence level by simulating 1,000 two-hour flight tests while propagating the orbits of the respective NGSO systems and deriving the PFD values necessary to ensure each two-hour flight test is protected. The resulting angle-independent adjacent band PFD limit for DC-MSS-IMT satellites providing service in the 2345-2360 MHz band to protect adjacent band AMT operations in 2360-2395 MHz is $-183.5 \text{ dB(W/(m}^2 \cdot 4\text{kHz))}$ (or $-159.5 \text{ dB(W/(m}^2 \cdot 4\text{kHz))}$) at any location on the surface of the Earth within the territory of the neighboring administration.³³ As explained in the study, the limit was derived and validated for angles of arrival of the emissions NGSO satellites (generally sidelobes in the cross-border situation) from 20° to 90°, inclusive, from the perspective of the AMT receiver location on the ground, irrespective of the instantaneous pointing angle of AMT antenna toward the test article.

Accordingly, AFTRCC proposes that a new *resolves n bis*) be inserted into the draft after sub-paragraph *resolves n*) in *resolves 4* of the DRAFT NEW RESOLUTION (DC-MSS-IMT) (WRC-27) appended to View A³⁴ setting forth the adjacent band PFD limit applicable to MSS systems supporting DC-MSS-IMT in the 2345-2360 MHz band:

n bis) In Region 2, for the purpose of protecting aeronautical mobile telemetry receive stations, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with a PFD limit of $-183.5 \text{ dB(W/(m}^2 \cdot 4\text{kHz))}$ applicable to the emissions from DC-MSS-IMT systems, per system, into the frequencies 2 360-2 395 MHz measured as the aggregate power flux-density by all space stations of a DC-MSS-IMT system in any 4 kHz band and for all methods of modulation, at the surface of the Earth at any point within the territory of the neighbouring administration at arrival elevation angles between 20° and 90°, inclusive, unless a different limit or other alternative is agreed upon

³³ See *id.*, at 17-18.

³⁴ See Notice, Att. A, at 161 of 240 (“View A Draft New Resolution”).

through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s).³⁵

VIII. THE PROPOSED ADJACENT CHANNEL PFD LIMIT IN VIEW B IS INADEQUATE TO PROTECT AMT

View B, which, like View A, calls for a secondary MSS allocation for DC-MSS-IMT in the 2345-2360 MHz band,³⁶ would impose, “for the protection of services operating in adjacent bands, . . . the following limits [sic] -120 dBW/m²/MHz” on DC-MSS-IMT systems.³⁷ This limit is equivalent to -144 dB(W/m²) over 4 kHz. View B, advanced by AST SpaceMobile, does not explain from where this proposed PFD limit was taken or, alternatively, how it was derived. There is no ITU-R contribution of which AFTRCC is aware that derives this PFD limit as sufficient to protect AMT operations. AFTRCC notes that View B’s proposed limit is equal to the adjacent channel PFD limit adopted by the Commission in the *SCS Order*.³⁸ However, there are several reasons why this PFD limit should not be borrowed from the domestic SCS context for protection of AMT and would be completely insufficient to protect AMT operations in the 2360-2395 MHz band.

First, the *SCS Order* specifically adopted this PFD limit in connection with the five original bands identified as eligible for SCS, none of which were adjacent to an AMT band. The Commission did not find that this limit would be sufficient to protect incumbent services in all

³⁵ See Appendix C, appended hereto, modifying the View A Draft New Resolution by adding new *resolves n bis*)).

³⁶ See Notice, Att. A, at 174 of 240 (proposed footnote 5.D113 would provide that “[t]he allocation to the mobile-satellite service on a secondary basis in the frequency band 2 300-2 400 MHz is limited to the frequency bands 2 305-2 320 MHz in the Earth-to-space direction, and 2 345-2 360 MHz in the space-to-Earth direction”).

³⁷ Notice, Att. A, at 179 of 240.

³⁸ *Single Network Future: Supplemental Coverage from Space*, GN Docket No. 23-65, IB Docket No. 22-271, Report and Order and Further Notice of Proposed Rulemaking (rel. March 15, 2024) (“SCS Order”).

bands adjacent to frequencies in which the Commission might authorize SCS or SCS-like services in the future. Demonstrative of this, and of particular relevance here, the Commission rejected identification of 2305-2320 and 2345-2360 MHz as initial SCS bands “given the serious concern that permitting SCS in this band could potentially interfere with important adjacent band operations” such as AMT.³⁹ If the -120 dBW/m²/MHz adjacent band PFD limit adopted in the case of the initial SCS bands was sufficient to resolve these interference concerns, the Commission could easily have said so. That it declined to do so makes clear that the -120 dBW/m²/MHz limit is inadequate to protect AMT in 2360-2395 MHz. And this is no surprise given that AMT receivers are highly sensitive given the need to receive telemetry data from aircraft that can be as far as 320 km (200 miles) away while performing dangerous test maneuvers as discussed above.

Second, a U.S. contribution authored by AST SpaceMobile itself, Document 4C/515, suggested an angle dependent “candidate” PFD mask far more strict than the View B proposed mask.⁴⁰ The origin or derivation of the “candidate” mask was never explained in Document 4C/515. Nonetheless, the following “candidate” was examined in that study by assuming that it was satisfied at all times by a system with a particular number of satellites (96) and orbital characteristics:⁴¹

³⁹ See *id.*, ¶¶ 32-34

⁴⁰ Document 4C/515, Figure 3.

⁴¹ The other technical and operational characteristics of the system in question, so-called System 4 as submitted into WP4C, were not needed for this portion of the study, given the methodology of Document 4C/515 which assumed consistent PFD limit compliance in order to test satisfaction of the M.1459 protection criteria of $I/N \leq -4.15$ dB for 99.5% or more of the time.

-180	dB(W/m ²)	for	$0^\circ \leq \alpha \leq 10^\circ$
$-202 + 2.2\alpha$	dB(W/m ²)	for	$10^\circ < \alpha \leq 20^\circ$
-158	dB(W/m ²)	for	$20^\circ < \alpha \leq 90^\circ$

Accordingly, the candidate mask was between 14 and 36 dB *more strict* than the PFD limit View B espouses. Significantly, when this earlier study stress-tested “candidate” mask, by conducting a simulation examining only one NGSO system over a cumulative 1,000,000 seconds (11.6 days) – and so considered *only average impacts* on flight testing rather than impacts within time periods representative of flight test activity, such as two hours – it found that the mask almost exactly satisfied the M.1459 protection criteria of $I/N \leq -4.15$ dB for 99.5% or more of the time.⁴² A subsequent U.S. study, Document 4C/691 extended the study considering the “candidate” mask by breaking the 1,000,000 period of flight test activity into 139 two-hour periods more representative of flight testing conducted in the United States.⁴³ These later results indicated that Document 4C/515, by looking at one million seconds as a whole, masked the fact that even though the NGSO system under study was presumed to satisfy the candidate mask continuously, *more than 40% of individual two-hour flight tests would suffer exceedances of the $I/N -4.15$ dB threshold for at least 0.5% of the time*; in other words, the M.1459 protection criteria were not satisfied by the NGSO system for almost one-half of all flight tests. See Figure 1 (copying Figure 6 of Document 4C/692). Additional results were presented in Document 4C/691 for test flight durations ranging from 15 minutes to 500,000 seconds within the period of 1,000,800 seconds. The results for each different duration showed exceedances of the -4.15 dB

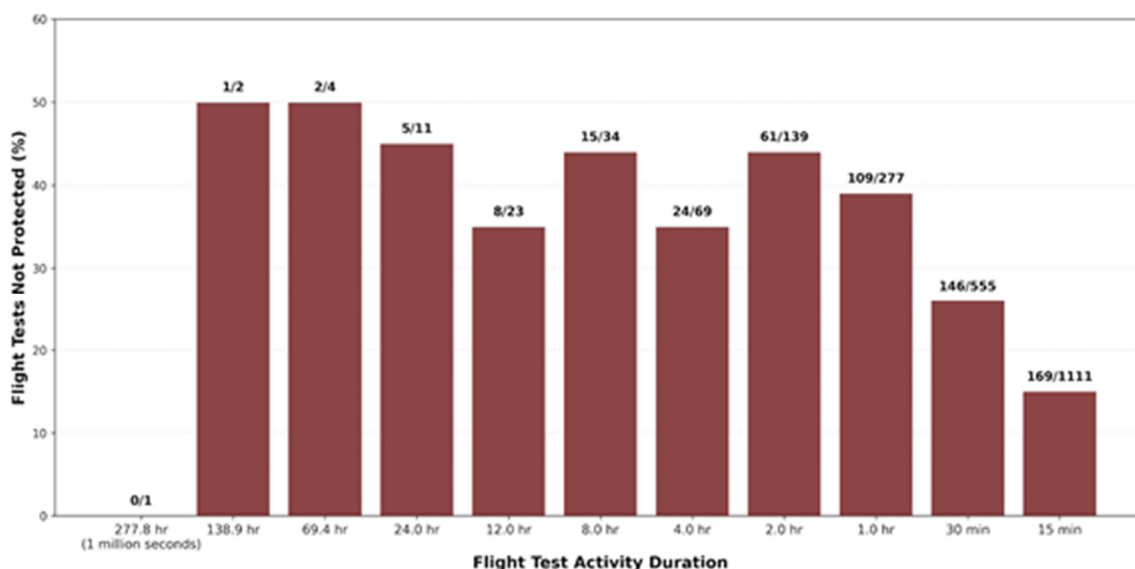
⁴² See Document 4C/515, Figure 5. Document 4C/515 made clear that “this study does not attempt to apply the 0.5% percentage-of-time criterion to a sample of individual flight tests.” *Id.* §3.1, p. 6.

⁴³ See Document 4C/691, §4, pp. 6-8.

thresholds for 0.5% or more of the time in a significant number of cases, underscoring the inadequacy of the candidate mask to ensure all flight tests would be protected to ensure reliable receipt of real-time telemetry.

FIGURE 1

Fraction of simulated test flights of varying lengths experiencing exceedances of the 0.5% of time and -4.15 dB I/N criteria when applied to varying durations of time



Document 4C/691 indicated that, for the particular system studied in Document 4C/515, the “candidate” mask would have to be reduced by approximately 7 dB, i.e., from approximately -187 dB(W/(m²·4kHz)) between 0° and 10° and 20° angles of arrival, to -158 dB(W/(m²·4kHz)), between 20° and 90°, with a linear increase from the value at 10° to the value at 20°. Document 4C/691 noted this reduction was not a finding of what the PFD mask should be but an extension of the work undertaken by Document 4C/515, where compliance with and operations within the limits set by the candidate PFD mask of Document 4C/515 was assumed.

The Aerospace Corp. Study fills in that gap left by Documents 4C/515 and 4C/691 by deriving a generally applicable angle-independent PFD limit for 2360-2395 MHz after

simulating thousands of two-hour test flights and the operations of three NGSO DC-MSS-IMT systems based on the operational and technical characteristics submitted into Working Party 4C. This is the only study available that derives a PFD mask through the conduct of such simulations of both the NGSO systems and AMT operations.⁴⁴

IX. ALTERNATIVE CRITERIA TO PROTECT AMT BASED ON I/N AND PERCENTAGE-OF-TIME WOULD BE DECIDEDLY INFERIOR TO A PFD LIMIT

AFTRCC has given some consideration whether, in lieu of PFD limits, it would be sufficient for the Resolution to require NGSO DC-MSS-IMT operators in the 2345-2360 MHz band to satisfy the M.1459 AMT protection criteria of $I/N \leq -4.15$ dB for 99.5% or more of the time.⁴⁵ While this may have a superficial appeal, there are several serious practical issues with this matter. As an initial matter, PFD limits are regularly used as regulatory requirements at the ITU-R. For example, Article 21, Table 21-4 includes numerous PFD limits applicable to MSS in numerous different frequency bands.⁴⁶ In contrast, the Radio Regulations (Volumes 1 through 3 – Articles, Appendices, Resolutions and Recommendations) only make three references to I/N in contrast with hundreds of references to PFD limits.⁴⁷ In addition, Views A, B, and C all propose PFD limits to protect incumbent services, and the NTIA draft proposal reflects the need in some bands for PFD limits. And Rec. ITU-R M.1459 itself derives PFD limits in its *recommends I*

⁴⁴ U.S. study Document 4C/696 fails to serve the purpose of filling in the gap to understand impacts on flight tests because it, like Document 4C/515 did *not* look at impacts during representative flight test periods but examined flight test activity over 24-hour periods.

⁴⁵ SpaceX vaguely suggests in its October 6 comments that protection criteria such as these should establish the regulatory requirements for DC-MSS-IMT operations. See SpaceX Comments at 3.

⁴⁶ ITU-R Radio Regulations No. 21.16 (“The power flux-density at the Earth’s surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limit given in Table 21-4.”)

⁴⁷ See, e.g., ITU-R Radio Regulations No. 5.225A.

and *recommends* 2 to apply to geostationary satellites, depending on frequency band, to protect AMT operations even though the Recommendation includes the protection criteria of $I/N \leq -4.15$ dB for 99.5% or more of the time from which the PFD limits were derived.

Further, PFD limits are objective in the sense that satellite network operators can design their deployments to meet PFD limits on the surface of the earth without reference to the receivers to be protected. Concomitantly, compliance can be confirmed based on the characteristics submitted to the Radiocommunication Bureau of the ITU with their notifications to the ITU. Therefore, a PFD limit is readily enforceable. In contrast, I/N is measured at the receiver. Unless there is advance agreement as to how the potential victim receivers are to be modeled, it would be practicably impossible for the satellite network operators to demonstrate compliance in advance. The use of I/N and percentage-of-time would impose undue burdens on the operators of the incumbent service to be protected, which is inappropriate especially where the new entrant, here MSS operators seeking to provide DC-MSS-IMT, is granted access on a secondary basis.

X. CONCLUSION

For the foregoing reasons, AFTRCC respectfully urges that for 1.13, that the United States, within Region 2, adopt a position calling a No Change position for the 1435-1525 MHz and 2360-2395 MHz bands given studies showing in-band harmful interference to AMT from DC-MSS-IMT system. A No Change position in these bands would be consistent with the NTIA draft proposal and View A which AFTRCC supports in this regard. To the extent that the U.S. position allows for an allocation to MSS for DC-MSS-IMT in the 2345-2360 MHz band, as suggested by View A, the U.S. should include a PFD limit applicable Region 2 of -183.5 dB(W/(m²·4kHz)) (or -159.5 dB(W/(m²·4kHz))) in the resolution applicable from 20° through

90° angle of arrival, inclusive. View B, including the proposed adjacent band PFD limit of -144 dB(W/(m²·4kHz))_(or -120 dB(W/(m²·4kHz))), should be rejected because U.S. studies submitted to Working Party 4C demonstrate that this PFD limit would be insufficient to protect safety-of-life AMT operations supporting flight tests within the United States. View C should also be rejected with regard to spectrum adjacent to the AMT bands discussed herein to the extent inconsistent with the positions AFTRCC takes herein.

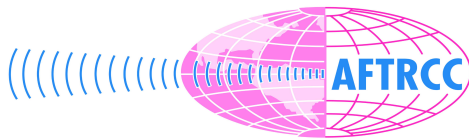
Respectfully submitted,

**AEROSPACE AND FLIGHT TEST RADIO
COORDINATING COUNCIL, INC.**



Jonathan Westerling
Acting President
P.O. Box 780481
Wichita, KS 67278

October 12, 2026



AEROSPACE & FLIGHT TEST RADIO COORDINATING COUNCIL, INC.®

AFTRCC Member Companies

Member Companies



Aerostar



Bell Helicopter Textron

BOMBARDIER

Bombardier - Learjet



Gulfstream Aerospace Corporation



Honda Aircraft Company



Joby Aviation

Lockheed Martin
Corporation - Aeronautics CompanyLockheed Martin
Corporation - Enterprise
Operations/Government AffairsNational Institute
for Aviation Research

Raytheon Technologies Corporation



Sikorsky - Lockheed Martin



Textron Aviation

The Boeing Company - Commercial
AirplanesThe Boeing Company - Defense and
Space

Virgin Galactic



Xwing, Inc.

Associate Members



CRFS, Inc.



Quasonix, Inc.



Peraton Labs

APPENDIX B

Proposed Power Flux Density Limits to Protect Aeronautical Mobile Telemetry Receiving Stations in the Frequency Bands 1 435-1 525 MHz, 1 780-1 850 MHz, and 2 360-2 395 MHz from Emissions of Non-GSO DC-MSS-IMT Systems

Technical study – 12 October 2026

Mark Lofquist, Ph.D.
Aerospace Corporation

1. Introduction

Several compatibility studies contributed by the United States to ITU-R Working Party 4C (Documents 4C/504, 691, and 692) demonstrate the potential for DC-MSS-IMT constellations being considered under WRC-27 AI 1.13 to cause cross-border harmful interference to safety-of-life aeronautical mobile telemetry (“AMT”) systems to well-established protection criteria. Accordingly, mitigation measures are needed to adequately manage the risks to AMT flight test operations and safeguard test flight pilots and crews, as well as persons on the ground.

These earlier studies focused on three sub-frequency bands under consideration in WRC-27 Agenda Item 1.13 (“1.13”) for potential allocations to the mobile satellite service (“MSS”) for DC-MSS-IMT in the frequency bands 1 452-1 525 MHz, 1 780-1 850 MHz, and 2 310-2 360 MHz. These studies utilized the antenna pattern and operating characteristics of AMT systems and the protection criteria found in Rec. ITU-R M.1459 (namely an interference-to-noise ratio (“I/N”) threshold of $I/N \leq -4.15$ dB to be satisfied more than 99.5% of the time). Those studies indicated that the maintenance of minimum separation distances between the service area of the DC-MSS-IMT system and primary, cross-border AMT receive sites is one measure that could be utilized to avoid such interference.

An alternative regulatory measure to be considered is the adoption of power flux-density (“pfd”) limits for DC-MSS-IMT satellite systems that would be applicable within the territory of the United States (and could also be used within the territories of other administrations that conduct AMT operations). While *recommends* 1 and 2 of Rec. ITU-R M.1459 provide pfd limits designed to protect AMT receivers, these limits were developed for single geostationary orbiting (“GSO”) satellites and did not consider the operation of non-GSO satellite constellations involving approximately one hundred or more, let alone thousands, of satellites where conjunctions between the mainlobes or sidelobes of non-GSO space station transmitters and an AMT receiver tracking a test flight article would occur more frequently, and at virtually any pointing azimuth and elevation, unlike the situation with an immobile GSO.

In short, this study develops angle-independent pfd limits adequate to protect AMT from DC-MSS-IMT satellite systems with time-varying non-GSO constellation geometries in the AMT

frequency bands 1 435-1 525 MHz, 1 780-1 850 MHz, and 2 360-2 395 MHz. To ensure that AMT flight test activity is consistently protected across all flights, ensuring efficiency of the flight test operations and safety of pilots, crews, and persons on the ground, the following limits should apply (between 20° and 90°, inclusive) to the aggregate pfd from all space stations of an NGSO DC-MSS-IMT system, in any 4 kHz band and for all methods of modulation, at any point on the surface of the Earth within the territory of the United States (or other countries conducting flight test operations):

- **Within the 1 435-1 525 MHz band: $-187.5 \text{ dB(W/(m}^2\cdot 4 \text{ kHz))}$**
- **Within the 1 780-1 850 MHz band: $-186.0 \text{ dB(W/(m}^2\cdot 4 \text{ kHz))}$**
- **Within the 2 360-2 395 MHz band: $-183.5 \text{ dB(W/(m}^2\cdot 4 \text{ kHz))}$**

As discussed herein, these pfd limits have been validated to ensure that they are neither overprotective nor underprotective relative to the Rec. ITU-R M.1459 protection criteria.

2. Development of Values to Protect Each Flight Test

This study develops angle-independent protective pfd limits at the surface of the earth at the border location that holds the AMT I/N against a non-GSO DC-MSS-IMT constellation at or below the Rec. ITU-R M.1459 threshold of $I/N \leq -4.15 \text{ dB}$ for more than 99.5% of the duration of each flight test.

Protection of each flight test using AMT from harmful interference during individual flight tests is essential. “Aeronautical telemetry and telecommand operations are used for flight testing of manned and unmanned aerospace vehicles. Vehicles are tested to their design limits, thus making safety of flight dependent on the reliability of information received on a real-time basis.” (Rec. ITU-R M.1459, § 2.1.) See also Rep. ITU-R M.2324, Annex 4, §1.1, “Sharing studies between potential International Mobile Telecommunication systems and aeronautical mobile telemetry systems in the frequency band 1429-1535 MHz,” quoting Rep. ITU-R M.2286, §1: “[Receipt of] AMT data is essential for the safety of pilots and persons on the ground during flight test activities as it is the critical source of real-time measurement and status information transmitted from airborne vehicles during live tests of manned and unmanned aircraft.”

Rather than an abstract spectrum-management objective balancing interests between AMT operations and other radiofrequency applications, guarding against “loss of availability” is “the prime concern” of the interference protection criteria in Rec. ITU-R M.1459 (§2.2.2). “[E]ven momentary interference can cause the AMT receive antenna tracking control loop to lose lock, or cause bit synchronization within the AMT digital receiver and bit de-commutator circuits to be lost. As a result, interference analyses must contemplate circumstances where the interference may occur even for only a few seconds.” (Rep. ITU-R M.2324, Annex 4, § 3.2.1.) Continuous and reliable reception of real-time telemetry from the test article during each test flight is

essential for operational assurance and flight safety. Loss of synchronization caused by interference can result in unrecoverable loss or reduced integrity of critical real-time data, can jeopardize the test article, its pilot(s), its crew, and persons on the ground, as well as require tests to be re-flown (introducing additional risks to safety).

Interference analysis must therefore consider time periods commensurate with individual flight tests, and even brief interruptions in the telemetry stream can threaten the safety and operational success of a flight test. In the extreme case where “the antenna control unit (ACU) loses lock, recovery of the AMT downlink can take many minutes, if it can even be accomplished without restarting the flight test segment. This is an expensive and time-consuming proposition and is not without risk to the flight crew and aircraft.” (Rep. ITU-R M.2324, Annex 4, § 3.2.1.)¹ Interference, even if it does not cause a loss of lock, can degrade the integrity and accuracy of the data and, therefore, the functioning of the safety-of-life AMT communications system. Such interference is equally harmful to that which causes a loss of availability or lock.

The ITU-R has underscored the need to protect all flight test activity from harmful interference not as a continuous service but during each individual test flight. “[AMT receive antennas] acquire [the] initial signal track prior to takeoff and track the vehicle throughout each flight.” (Rep. ITU-R M.2286, §2.1.) “AMT provides extra eyes on the ground. Specialists in structural integrity, flying qualities, and propulsion systems, to name just a few systems, continuously monitor vehicle or subsystem status in their respective specialties and advise test conductors whenever anomalous or unexpected behavior is detected. In turn, test conductors prioritize these inputs and are able to warn the pilots as necessary in order to avoid catastrophic failures. These and other safety-related tests (such as “flutter” tests designed to stress wings and control surfaces) leave no margins for error.” (Rep. ITU-R M.2286, §3.1.) Beyond safety considerations during individual flights, reliable receipt of telemetry data during each flight test is an indispensable diagnostic tool of test vehicle systems. “If a major failure occurs (fortunately an infrequent event), ground recordings of telemetry data are often the only source of diagnostic information to support accident investigation. This is particularly true for test vehicles that are not recoverable. AMT data recorded by receiving stations prior to TA loss is the only means of knowing how and why particular outcomes occurred.” (Rep. ITU-R M.2286, §3.2.)

Reliable real-time receipt of telemetry data also directly impacts productivity. “Consistent with safety, the purpose [of real-time availability and evaluation of data] is to accelerate test schedules, thereby reducing or at least controlling the huge, escalating costs of testing, and accelerating time-to-market.” (Rep. ITU-R M.2286, §3.3.) Assessment of the telemetry data

¹ Rep. ITU-R M.2324, Annex 7, §4(1) describes the significance of selecting an appropriate duration of flight tests for interference and compatibility analyses. “We have used as an example typical telemetry testing and created a model where each ground telemetry site has trials occurring up to 8 hours a day for 5 days per week... In spite of these assumptions, the current study cannot be served as a best case for sharing studies provided that: – flight procedure test durations are generally shorter than 8 hours (2-3 hours).”

received in real time dictates the scope of an individual flight test. “If no critical safety limits are reached, these specialists are responsible for determining if conditions are consistent with immediate progression to the next scheduled test during the same flight.” (Rep. ITU-R M.2286, §3.3.)

2.1 AMT system characteristics

This study employs the reference AMT receiving station characteristics as specified in Rec. ITU-R M.1459. These were also used in the WP4C studies referenced above.

Working Party 5B has confirmed in its reply liaison statements that the technical information on AMT set forth in Recommendation ITU-R M.1459 is suitable and appropriate for use in studies involving non-GSO MSS satellite constellations (see, e.g., most recently Document 4C/360). This guidance ensures that the technical information regarding AMT systems set out in Rec. ITU-R M.1459 can be directly applied to electromagnetic compatibility analyses involving non-GSO systems.

Annex 1, Section 2.2.4 of Rec. ITU-R M.1459 determines that the maximum allowable INR from a satellite source into AMT receivers is $\text{INR} \leq -4.15 \text{ dB}$ and sets a maximum non-availability probability threshold of 0.5%.

Even when the MSS space station is not within or near the boresight of the AMT antenna, interference from the MSS downlink sidelobes exceeding the INR criterion may occur given the gain of the AMT antenna’s sidelobes.

The AMT antenna pattern used in the study is taken from Rec. ITU-R M.1459 Annex 1, Section 2.1, equations (1a) – (1f); these are reproduced below, and a visual representation of the antenna pattern is shown in Figure 1.

$$G(\theta) = 41.2 + 20 \log \left(\frac{\sin(1.952\theta)}{1.952\theta} \right) \quad \text{dBi for } 0^\circ \leq \theta \leq 0.94^\circ \quad (1a)$$

$$G(\theta) = 35.1 - 20 \log \theta \quad \text{dBi for } 0.94^\circ < \theta \leq 3.82^\circ \quad (1b)$$

$$G(\theta) = 29 + 20 \log \left(\frac{\sin(0.479\theta)}{0.479\theta} \right) \quad \text{dBi for } 3.82^\circ < \theta \leq 5.61^\circ \quad (1c)$$

$$G(\theta) = 27.27 - 18.75 \log \theta \quad \text{dBi for } 5.61^\circ < \theta \leq 12.16^\circ \quad (1d)$$

$$G(\theta) = 34.05 - 25 \log \theta \quad \text{dBi for } 12.16^\circ < \theta \leq 48^\circ \quad (1e)$$

$$G(\theta) = -8 \quad \text{dBi for } 48^\circ < \theta \leq 180^\circ \quad (1f)$$

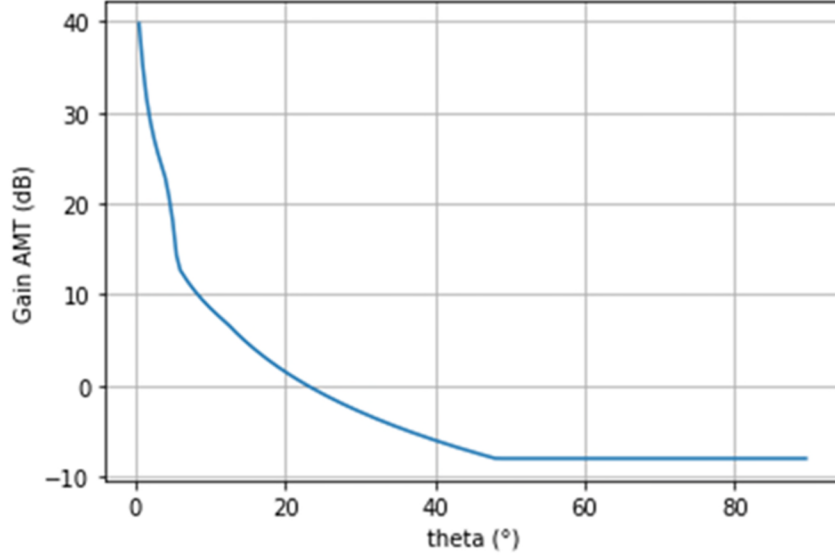


Figure 1: AMT antenna pattern used for analysis

The highest receiving antenna gain is 41.2 dBi (corresponding to $G_0 = 13\,183$), the receiving system noise temperature is $T = 250$ K, and the reference bandwidth is $B = 4$ kHz. The AMT receiving antenna continuously tracks an airborne test vehicle. The gain toward a satellite is therefore a function of the off-axis angle ψ between the AMT antenna boresight and the satellite direction. The wavelength is $\lambda = c/f$, where c is the speed of light and f is the frequency used in the simulations for the band under study (Table 6).

Using the above parameters, I/N at the AMT receiver is calculated with the following equations:

$$N = kTB \quad (2)$$

$$I/N \leq 0.3846 = -4.15 \text{ dB} \quad (3)$$

where N is the internal receiver noise power, k is Boltzmann's constant, and I is the interference power at the AMT receiver from satellite sources in the reference bandwidth. For the reference values $T = 250$ K and $B = 4$ kHz, the receiver noise power is -168.60 dBW in 4 kHz.

The receiver model and the test aircraft flight profile are the same as those used in Doc. 4C/692. Specifically, for each simulated flight test, the aircraft executes a single 7 200-second (two-hour) flight in an elliptical path with major axis of 640 km and minor axis of 10 km, and the off-axis angle from the receiver to each satellite sets the receive gain at every instant. The flight altitude is 50 000 feet (15.24 km). The study determines the pfd limits that would protect each 7 200-second test flight simulated, given the safety-of-life aspects of flight test operations dependent on reliable real-time receipt of the telemetry from the test aircraft. *See* Rec. ITU-R M.1459, § 2.1 (“[v]ehicles are tested to their design limits, thus making safety of flight dependent on the reliability of information received on a real-time basis”).

2.2 DC-MSS-IMT MSS Systems Utilized in the Study.

In this study, the system characteristics of two DC-MSS-IMT satellite constellations – System 3 (including System 3A and 3B) and System 4 – are taken from Doc. 4C/744, Annex 10, Part 1. The system characteristics of Systems 3A, 3B and 4, as set out in Doc. 4C/744, Annex 10, Part 1 and used in Doc. 4C/692, are reproduced in Tables 1–3, and their antenna patterns in Figures 2 and 3.

TABLE 1
System 3A orbital configuration

Altitude	525 km
Inclination	53°
Number of planes	28
Satellites per plane	120
RAAN spacing	12.9°
Total number of satellites	3360
Minimum service elevation angle	20°
Maximum pfd on the ground per beam (dBW/m ² /MHz)	−87.9 at 1.5 GHz (−111.9 dBW/m ² /4 kHz)

TABLE 2
System 3B orbital configuration

Altitude	340 km
Inclination	53°
Number of planes	48
Satellites per plane	110
RAAN spacing	7.5°
Total number of satellites	5280
Minimum service elevation angle	20°
Maximum pfd on the ground per beam (dBW/m ² /MHz)	−86.9 at 1.5 GHz (−110.9 dBW/m ² /4 kHz)

TABLE 3
System 4 orbital configuration

Altitude	690 km
Inclination	53°
Number of planes	96
Argument of Perigee	90°
Sats per plane	1
RAAN spacing	Orbital planes start at 1.875° and subsequent planes are offset by 3.75°

TX power	-3.6 dBW/MHz
Phase angle	Satellite starts at 48.75° from plane 1 and satellites in subsequent planes are offset by 97.5°
Total number of satellites	96
Minimum service elevation angle	32°
Average pfd on the ground per beam (dBW/m ² /MHz)	-90.4
MSS Downlink Antenna Pattern	See Figure 3

2.2.a Systems 3A and 3B Antenna Pattern

The DC-MSS-IMT system antenna patterns (which were used in Doc. 4C/692) are reproduced below.

Figure 2 shows the MSS antenna pattern used for Systems 3A and 3B for the simulation.

For the co-channel antenna pattern, Rec. ITU-R S.1528, recommends 1.4 was used with the fixed parameters from the Doc. 4C/744, Annex 10, Part 1 embedded spreadsheet. It is noted that the electrical size D/λ is constant, eliminating the need to scale λ independently depending upon frequency band.

There are two frequency-dependent terms in the link budget: EIRP spectral density and free-space path loss. Values for the 1 427-1 518 MHz, 1 710-2 025 MHz and 2 300-2 400 MHz bands are taken from the Doc. 4C/744, Annex 10, Part 1 spreadsheet.

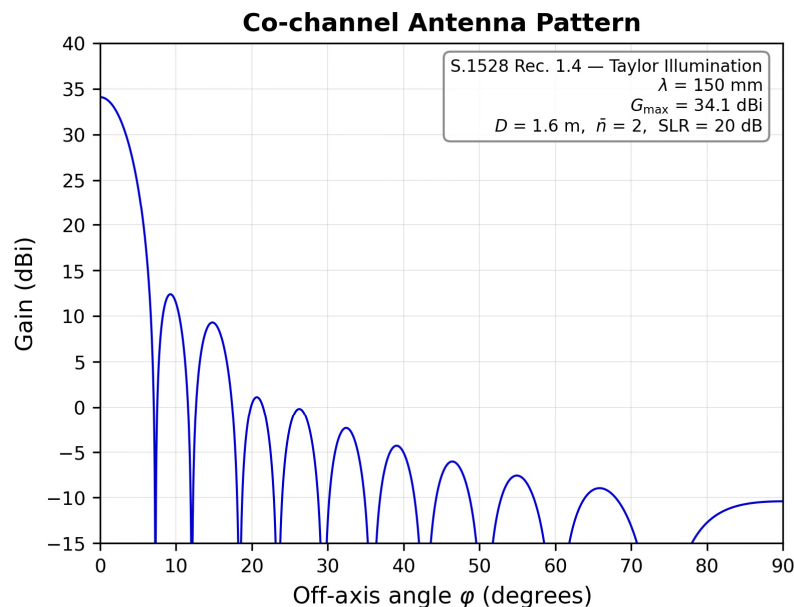


Figure 2: Systems 3A and 3B MSS antenna pattern used for analysis. $\lambda = 150$ mm and $D = 1.6$ m are the fixed values of Doc. 4C/744, Annex 10, Part 1; only $D/\lambda \approx 10.7$ enters the pattern, which was applied unchanged in all three AMT bands.

2.2.b System 4 Antenna Pattern

In accordance with Rec. ITU-R S.1528, recommends 1.1, the MSS antenna patterns used in the simulation are based on real-world reference patterns for System 4. The beam pattern plots published in Annex 10, Part 1 of Document 4C/744 were digitized pixel-by-pixel to extract tabulated gain (dBi) versus off-boresight angle for three beamformer look angles corresponding to service elevation angles of 90°, 45°, and 32° relative to the UE, with separate E-plane and H-plane gain profiles produced for each.

For intermediate elevation angles, the three digitized reference patterns were combined using inverse-squared-distance-weighted interpolation, with weighting factor $w_i = 1/|\varepsilon - \varepsilon_{ref,i}|^2$, where ε is the actual MSS-UE elevation angle and $\varepsilon_{ref,i}$ is the elevation of reference pattern i . The E-plane antenna pattern boresight location shifts based on satellite elevation angle, so the three E-plane reference patterns are shifted to align at the expected boresight location corresponding to the real elevation angle before they are combined; this is not required for the H-plane, where all three reference pattern boresights are at 0°.

Figure 3 shows example E- and H-plane antenna renderings, including for the critical System 4 service angles of 90°, 45°, and 32°, the minimum service angle for MSS downlinks from the perspective of the UE being served.

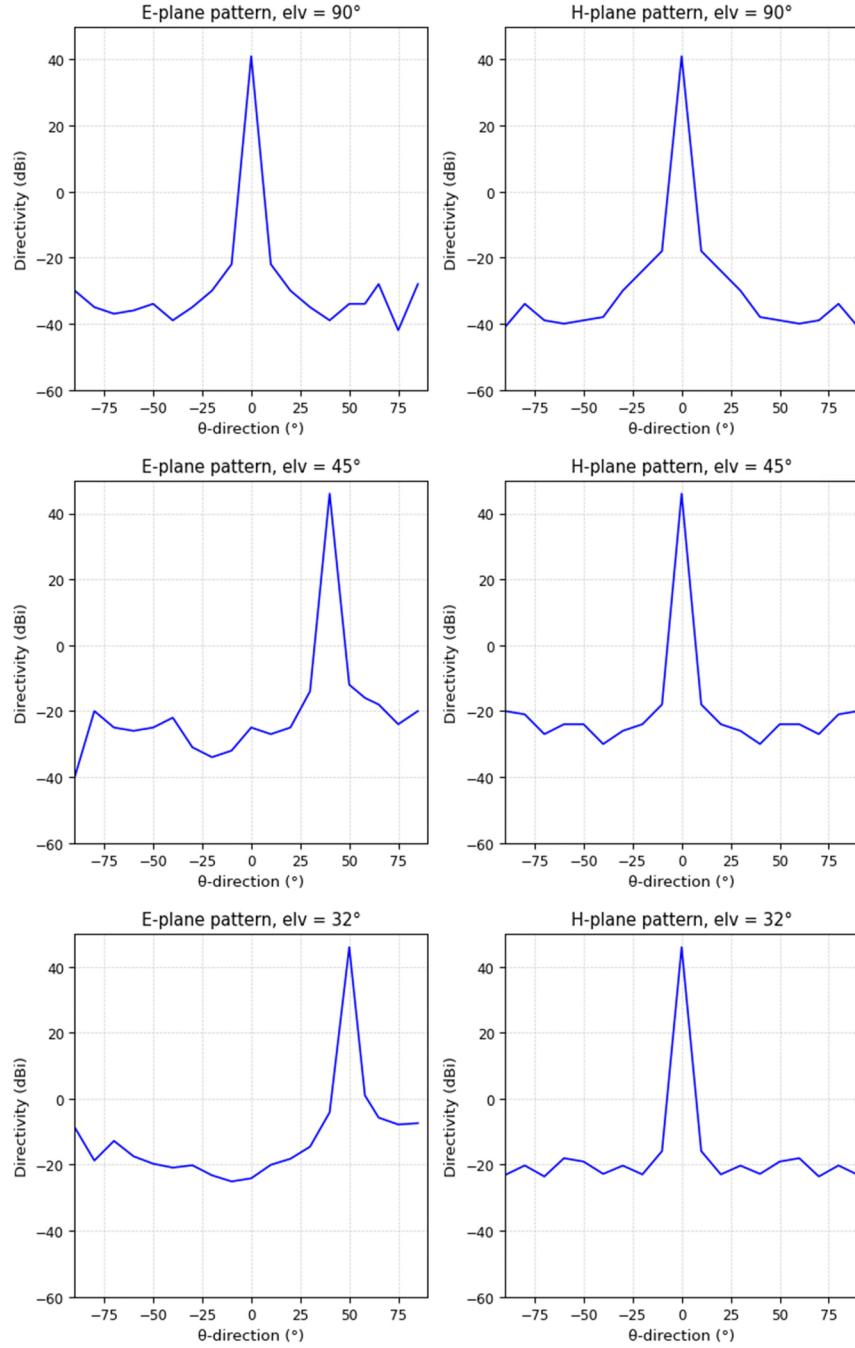


Figure 3: Example System 4 MSS antenna patterns used for analysis, including critical service elevation angle of 32° relative to the UE being served

2.3 Definitions

See Figure 4 for the geometry between the AMT receive station tracking the test aircraft and a given MSS satellite from the constellation, with definitions of the variables in Table 4 below the Figure.

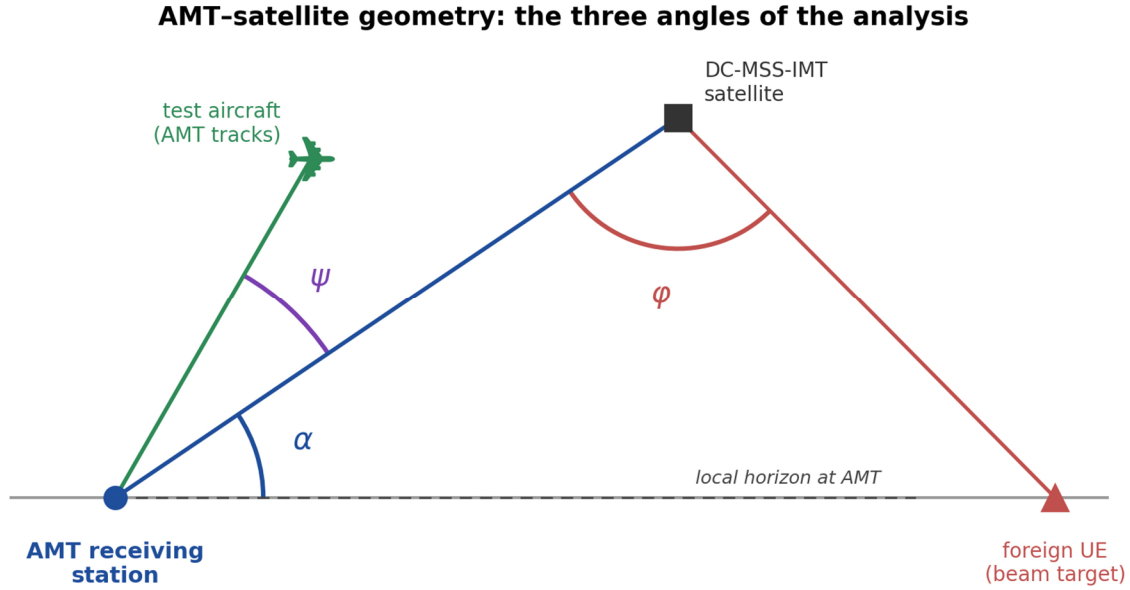


Figure 4: AMT Receive Station and DC-MSS-IMT satellite geometry — the arrival angle α (satellite elevation at the AMT receiver), the AMT off-axis angle ψ (AMT receiver flight test tracking boresight relative to DC-MSS-IMT satellite), and the satellite off-axis angle ϕ (satellite beam axis to DC-MSS-IMT user equipment relative to AMT receiver site).

TABLE 4

Symbol	Definition	Unit
α	Angle of arrival of the interfering satellite emission at the surface of the earth at the border location above the local horizontal plane. This is the reporting variable for the pfd values.	degrees
ψ	Off-axis angle between the AMT antenna boresight, which tracks the aircraft, and the direction to the interfering satellite. This is the angle used in the AMT receive antenna pattern.	degrees
ϕ	Satellite off-axis angle (angle between satellite main beam axis to DC-MSS-IMT user equipment and AMT receiver site from perspective of the satellite).	degrees

$\text{pfd}_{\text{beam}}(\alpha)$	Power flux-density delivered at the surface of the earth at the border location by one active satellite beam in the reference bandwidth.	dB(W/(m ² ·4 kHz))
$\text{pfd}_{\text{sat}}(\alpha)$	Power flux-density delivered at the surface of the earth at the border location by one satellite, summed over all simultaneously active beams from that satellite in the reference bandwidth.	dB(W/(m ² ·4 kHz))
I/N	Satellite interference-to-noise ratio calculated at an AMT receiving station.	dB

The angle α is used for reporting a pfd value as in Rec. ITU-R M.1459. The angle ψ is used for the AMT receiving antenna gain because the AMT antenna points toward the test aircraft, not, except for chance configurations, toward the interfering satellite as shown in Figure 4. Pursuant to satellite selection rules in Doc. 4C/744, Annex 10, Part 1 for each NGSO system, one satellite in the constellation aims its beam at the UE being served at the border location closest to the AMT receive station presumed to be 5 km from the border. The other satellites in the constellation not serving that UE are presumed to serve a more distant UE presumed to be at each satellite's nadir.

2.4 Aggregate and single-entry pfd for peak alignment

The aggregate satellite constellation contribution to AMT interference described in Rec. ITU-R M.1459, §2.2.4 – $(I/N)_S \leq 0.385$, from the apportionment $I_S = 0.25(N_I + I_S + I_T)$ – is measured against the interference criterion of -4.15 dB at every interval in the simulations. The criterion is deterministic, and this study evaluates exceedances of it against the 0.5% percentage-of-time criterion found in the Recommendation. (Rec. ITU-R M.1459, §2.2.4 separately adopts a telemetry-link non-availability probability $P = 0.005$). In practice, however, the simulations demonstrate one satellite will dominate, and the aggregate contribution of all other satellites is typically less than 2.9 dB above the dominant contribution (the 95th percentile of the governing time steps; 3.6 dB at the maximum), as explained in Section 2.5.2, step 1.

When the telemetry receiving antenna is pointed toward a satellite, the pfd corresponding to the satellite interference (the -4.15 dB I/N criterion) is obtained from the same relation as Rec. ITU-R M.1459, Annex 1, equation (8), labeled here as the single-entry floor (equivalently a dominant satellite beam aggregate floor with a single emission delivering the full aggregate allowance as a practical matter through the main beam). Across the validation ensembles of Section 3, the satellites other than the dominant one add, in combination, typically less than 2.9 dB to the dominant contribution. Each two-hour flight's 36th largest I/N (out of 7200 intervals) in the AMT receiver is the " $I/N_{36\text{th}}$ ". If the $I/N_{36\text{th}}$ is above -4.15, the flight is a Flight Test Not Protected.

The protective limits of Section 3 are derived with the full incoherent aggregate at every time step, so this bounded non-dominant contribution is embedded in the result and no separate aggregation adjustment is applied to equation (4):

$$pfd \leq \frac{kTB(I/N)}{G_0\lambda^2/4\pi} \text{ W/m}^2 \quad (4)$$

2.5 Simulation

2.5.1 Overview of Methodology and Simulations

In each of the three AMT bands, the impact of each DC-MSS-IMT system on presumed AMT locations just inside the U.S. northern and southern borders is studied separately as follows. The constellation of each DC-MSS-IMT system is simulated using the orbital parameters from Doc. 4C/744, Annex 10, Part 1 set out above in Tables 1-3 above. Further, the per-beam EIRP density (Systems 3A and 3B) and the constant pfd on the ground (System 4) is presumed at each UE being served. See Tables 1-3 above. An AMT receiver presumed located just inside the U.S. border over a two-hour test flight is simulated tracking a test flight article with technical parameters taken from Rec. ITU-R M.1459. Each band, system, and location combination is referenced here as an “ensemble.”

Each simulation of 1 000 test flights for each ensemble propagates the constellation in time and measures the pfd delivered at the border AMT location and the resulting I/N at each one-second interval over the two hours (7200 seconds) for each flight test. The largest I/N_{36th} among the 1 000 flight tests simulated in each ensemble is the “Largest I/N_{36th}”. The reduction in emission level, from the EIRP density (Systems 3A and 3B) or ground pfd (System 4) submitted in Doc. 4C/744, Annex 10, Part 1, required to ensure there are no Flight Tests Not Protected in that ensemble is the amount by which the Largest I/N_{36th} exceeds the Rec. ITU-R M.1459 I/N criterion of –4.15 dB. Because I/N scales dB-for-dB with the satellite emission, reducing the emission by that amount places the Largest I/N_{36th} at the Rec. ITU-R M.1459 I/N criterion of –4.15 dB in a single step. The pfd at the AMT receiving station at the reduced emission level is the protective pfd value for that ensemble; the angle-independent protective pfd limit for each band is the most restrictive of those values across systems and border locations, which is then tested on an independent set of randomized flight tests to confirm that, as an angle-independent pfd limit, it is both sufficient and not more restrictive than necessary.

2.5.2 Detailed Description of the Simulation

The interferer is a DC-MSS-IMT constellation transmitting at its target EIRP or pfd on the ground to serve UEs (Doc. 4C/744, Annex 10, Part 1) across the U.S. border from the presumed near-border AMT receive sites. A single AMT receiving station is placed 5 km inside the northern border and another 5 km inside the southern border. A UE is presumed to be just beyond the closest border location; others are at the nadir of each satellite not serving the UE 5

km away from the AMT site. Of interest is the pfd these DC-MSS-IMT emissions deliver to each AMT site when UEs are being served across the border. The criteria for protection are $I/N \leq -4.15$ dB for more than 99.5% of every 7 200-second flight test. 1 000 two-hour flight tests are simulated for each border location, for each system, in each band.² This per-flight application follows the structure of the Recommendation itself. The non-availability $P = 0.005$ of Annex 1, §2.2.4, is a property of each telemetry link operation. An availability figure attaches to the operation it protects, so the 99.5% availability of Rec. ITU-R M.1459 in and of itself implies application to the individual flight test activity. Aerospace vehicles are tested to their design limits, and safety of flight as well as the efficacy of the flight test exercise depend on the integrity of information received in real time (Rec. ITU-R M.1459, §2.1). Even momentary interference can cause the receive antenna tracking loop to lose lock (Report ITU-R M.2324, Annex 4, §3.2.1; see also Report ITU-R M.2286).

Procedure. The control factor is the Largest I/N_{36th} and, from it, the required angle-independent protective pfd adjustment can be derived. The steps below are carried out in full for each of the three AMT bands and each of the three DC-MSS-IMT Systems under study (3A, 3B and 4), separately at northern and southern U.S. border locations, with DC-MSS-IMT constellations serving cross-border UEs at a 5 km separation. Site latitude is a control factor because each system studied has an orbital inclination of 53 degrees, so the number of space stations simultaneously in view of a site increases with latitude toward that value; across the cases examined the northern border location is more demanding than the southern border location, by 1.1 dB for System 3A, 1.9 dB for System 3B and 7.2 dB for System 4. The limit proposed in each band is the most restrictive result across systems and border locations.

1. How loud is the service pfd at an assumed cross-border AMT receiving station with a separation distance of 5 km? Each system is set to the EIRP density (Systems 3A and 3B) or constant ground pfd (System 4) submitted in Doc. 4C/744, Annex 10, Part 1 needed to serve its UEs (Tables 1-3). The constellation is stepped through a 7 200-second flight test at one-second intervals while the AMT antenna inside the border tracks its test aircraft on the Doc. 4C/692

² One thousand (1 000) trials are run in each iteration (for each system, in each band, for each AMT location) to establish a high confidence level that all flight tests will be protected through compliance with the angle-independent protective pfd limit within the AMT bands. The confidence level is established using the Clopper-Pearson one-sided upper confidence bound for the binomial parameter (Clopper and Pearson, *Biometrika*, Vol. 26, No. 4, 1934, pp. 404–413). Each of the 1 000 trials is initialized at a random epoch drawn uniformly over the constellation precession, as explained earlier, yielding an independent satellite-to-AMT geometry per trial. If all flight tests are protected consistent with the Rec. ITU-R M.1459 protection criteria in $N = 1$ 000 independent trials, $p_{upper} = 1 - \alpha^{(1/N)}$. At $\alpha = 0.01$, this gives $p_{upper} \approx 4.6 \times 10^{-3}$ for $N = 1$ 000 and 5.8×10^{-4} for the $N = 8$ 000 independent validation trials of Section 2.5.2, step 3, confirming at 99% confidence that the per-test probability of a flight test not protected does not exceed 0.5%.

A4.1 profile - an ellipse of 640 km major axis and 10 km minor axis at 50 000 feet - each trial initialized at a random epoch drawn uniformly over the constellation's precession. At each second, for each serving satellite, the slant range d , the off-axis angle ϕ and the angle of arrival α are computed, and the flux delivered is $\text{pfd beam} = \text{EIRP}_S + G_{\text{rel}}(\phi) - 10 \log_{10}(4\pi d^2)$, in dB(W/(m²·4 kHz)), with $G_{\text{rel}}(\phi)$ taken to its actual far-sidelobe levels and no artificial floor. Each beam is received through the Rec. ITU-R M.1459 AMT antenna $G_{\text{AMT}}(\psi)$ and summed incoherently over all simultaneously serving satellites to form the aggregate $I/N(t)$. One satellite dominates at every governing time step; the remainder of the constellation adds a bounded increment, at most 3.6 dB and typically below 2.9 dB at the 95th percentile, which is included in the sum.

2. The 36th-largest I/N within each 7 200-second flight test (the $I/N_{36\text{th}}$) determines whether that flight test is protected, i.e., suffers exceedances of the Rec. ITU-R M.1459 AMT protection criteria. The Largest $I/N_{36\text{th}}$ is then identified, and the amount by which it exceeds -4.15 dB yields the pfd value necessary in the same frequencies at the UE to ensure there are no Flight Tests Not Protected on a cross-border basis. Because I/N scales dB-for-dB with the emission level, reducing the emission by that amount places the Largest $I/N_{36\text{th}}$ at the Rec. ITU-R M.1459 criterion in a single step, neither over- nor under-protecting. The realized pfd at the border location at the reduced emission level, bounded below by the Rec. ITU-R M.1459 single-entry value of equation (4), is the protective pfd value for that ensemble; the most restrictive such value across systems and border locations is the angle-independent protective pfd limit, a single value applying at every angle of arrival.

3. An independent validating set of 8 000 flight tests, separate from the 1 000 used in the derivation, generated from a separate trial stream, is run for the bounding system, System 3A, to confirm that the derived angle-independent protective pfd limit is sufficient and not more restrictive than necessary. The sufficiency of the derived angle-independent protective pfd limit was confirmed at each border location and in each band (Table 7). Acceptance is determined by the one-sided 99% Clopper-Pearson upper bound on the proportion of Flight Tests Not Protected.

3. Results

At the emission levels of Doc. 4C/744, Annex 10, the amount by which the Largest $I/N_{36\text{th}}$ for each DC-MSS-IMT system, border location and band exceeds the Rec. ITU-R M.1459 criterion of -4.15 dB is given in Table 5. Remaining at or below this pfd value at all angles of arrival at the border location (and within the territory of the neighboring administration) will ensure that the Rec. ITU-R M.1459 criteria are met (I/N above -4.15 dB for less than 0.5% of each flight test). Figure 5 demonstrates and characterizes the distribution of $I/N_{36\text{th}}$ values for each of the 1 000 flight tests in one ensemble: System 3A operating in the 1 435-1 525 MHz band at an AMT receive station located at the northern border (the governing scenario for the band).

The resulting pfd limits found are less restrictive than those calculated from $I/N = -4.15$ dB in Equation 4 and Table 6 by 1.4 to 1.5 dB after rounding down to the nearest 0.5 dB, which accounts for both aggregate interference contributions from all visible satellites and the 0.5%-of-time criterion in Rec. ITU-R M.1459.

TABLE 5

Band	System	Filed EIRP spectral density per beam or ground pfd (Doc. 4C/744, Annex 10, Part 1)	Excess I/N at AMT site
1 435–1 525 MHz	3A (governing)	-22.5 dBW/Hz @EL 90°	+75.18 dB
	3B	-22.5 dBW/Hz @EL 90°*	+76.08 dB
	4	-114.4 dB(W/(m ² ·4 kHz))**	+63.46 dB
1 780–1 850 MHz	3A (governing)	-20.1 dBW/Hz @EL 90°	+76.19 dB
	3B	-20.1 dBW/Hz @EL 90°	+79.90 dB
	4	-114.4 dB(W/(m ² ·4 kHz))**	+62.08 dB
2 360–2 395 MHz	3A (governing)	-18.1 dBW/Hz @EL 90°	+75.63 dB
	3B	-18.1 dBW/Hz @EL 90°*	+76.54 dB
	4	-114.4 dB(W/(m ² ·4 kHz))**	+59.52 dB

Reference pfd per beam: the nadir pfd at the EIRP density shown (Systems 3A and 3B), or the filed maximum ground pfd (System 4), Doc. 4C/744, Annex 10, Part 1. * For System 3B the study used -25.3 dBW/Hz (1 435–1 525 MHz) and -20.9 dBW/Hz (2 360–2 395 MHz), 2.8 dB below the filed values; -25.3 dBW/Hz reproduces System 3B's filed maximum ground pfd of -86.9 dB(W/(m²·MHz)) at nadir in 1 427–1 518 MHz, and the same offset was applied in 2 300–2 400 MHz, for which no ground pfd is filed. ** System 4 files an EIRP spectral density of -22.6 to -17.6 dBW/Hz with +10 dB to -10 dB of power control on each beam, and a maximum pfd on the ground per satellite of -90.4 dB(W/(m²·MHz)) (-114.4 dB(W/(m²·4 kHz))) in all bands. Excess I/N at AMT site: amount of Largest I/N_{36th} above -4.15 dB when every space station delivers the reference pfd.

TABLE 6

AMT Band	Frequency used in the simulations	pfd from equation (4) (dB(W/(m ² ·4 kHz)))
1 435-1 525 MHz	1 518 MHz	-188.87
1 780-1 850 MHz	1 780 MHz	-187.49
2 360-2 395 MHz	2 390 MHz	-184.93

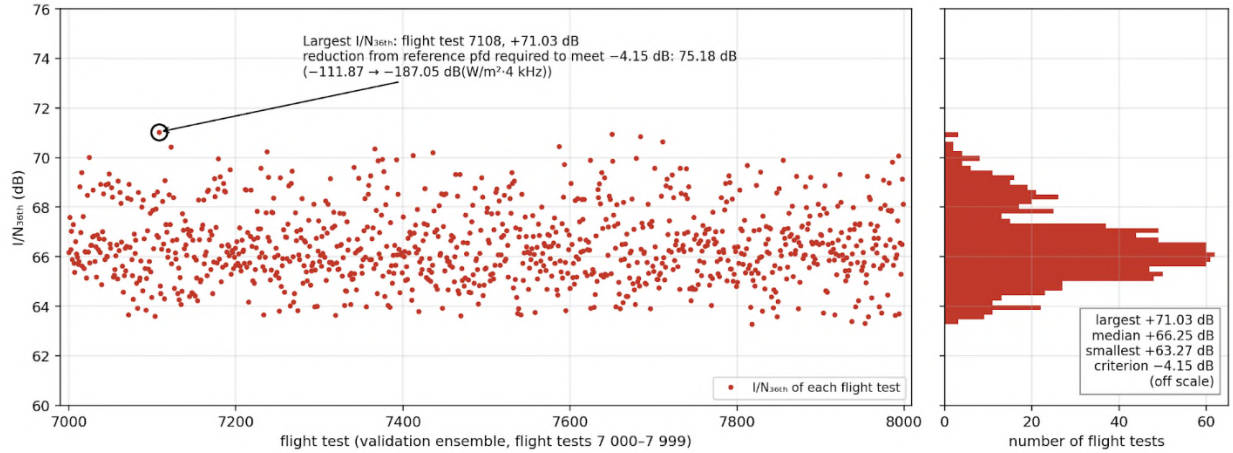


Figure 5: Distribution of I/N_{36th} values for each of 1 000 AMT flight tests with System 3A operating in the 1 435-1 525 MHz band at an AMT location at the northern border.

The study yields for each AMT band an angle-independent protective pfd limit: a single value applying at every arrival angle, that is not specific to any one system. Consistent with Rec. ITU-R M.1459, it is evaluated at a cross-border location – the pfd it limits is the aggregate pfd from all space stations of the DC-MSS-IMT system within the territory of the neighboring administration with AMT operations to be protected, not the pfd a satellite delivers within its service area. Because the aggregate pfd is never less than the pfd from any one space station, a limit on the aggregate is at least as protective as the per-space-station value derived and validated here. A satellite serving user equipment located away from the border meets the limit through the combination of its emission level in the AMT band and its off-axis discrimination $G_{rel}(\varphi)$ toward the surface of the earth at the border location (and within the territory of the neighboring administration). Compliance at an AMT receiving station thereby bounds the pfd a satellite may deliver to user equipment in the vicinity of that station – in this simulation 5 km distant – and is more easily achieved as the separation, and, with it, φ , increases.

The near-station case is bounded by geometry rather than by statistics: a user equipment served 5 km from an AMT receiving station subtends an off-axis angle at the satellite of less than 0.85 degrees in every system studied - 0.55 degrees for System 3A at zenith and 0.23 degrees at its minimum service elevation (presumed to be 20 degrees). At those angles the AMT receiving station lies within the serving main beam, essentially no off-axis discrimination is available, and the pfd at the AMT receiving station approaches the full main-beam value delivered to the served user equipment.

The angle-independent protective pfd limit in each band is given in Figure 6 and applies at every angle of arrival at or above 20 degrees. System 3A binds the derivation. Systems 3A and 3B each have a submitted minimum service elevation of 20 degrees; System 4 has a 32-degree minimum service elevation. No regulatory pfd value is derived in this study below 20 degrees. Further study would be necessary to determine if the angle-independent pfd values derived

herein would be protective if they applied below 20 degrees angle of arrival. Values are rounded downward from the full-precision values used in the validation to the nearest 0.5 dB, so publication rounding does not increase any proposed limit.

The three band values differ only by the frequency offset $20 \log_{10}(f_2/f_1)$, because the transmit-side relative pattern is band-independent and the receive coupling scales only through the $\lambda^2/(4\pi)$ aperture term.

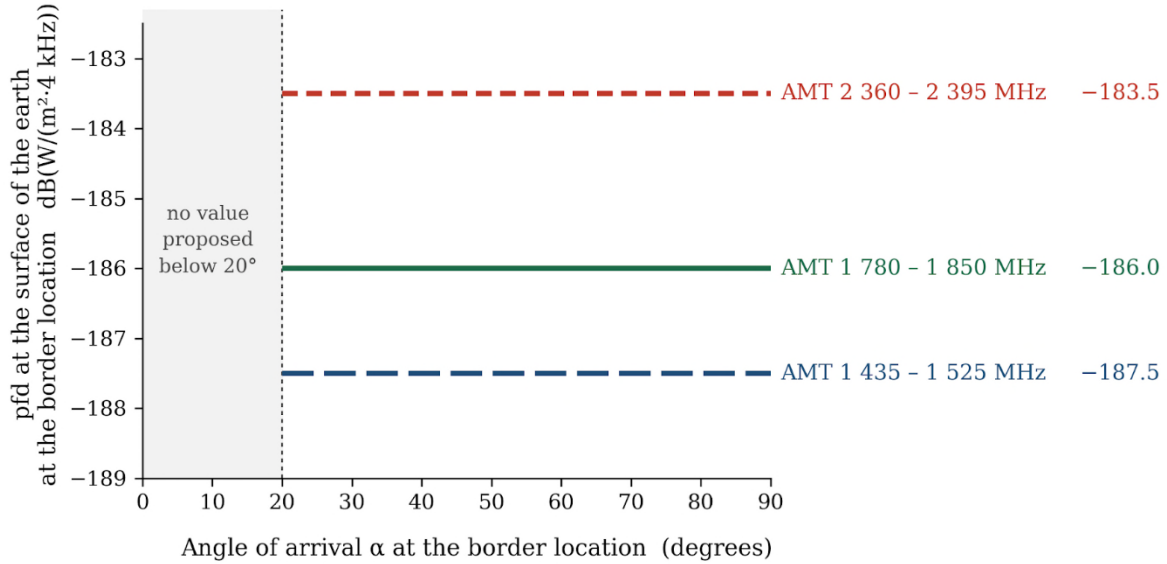


Figure 6: Angle-independent protective pfd limit at an AMT receiving station. One value per AMT band, applying at every angle of arrival at or above 20 degrees (the presumed minimum angle of arrival based on Doc. 4C/744 Annex 10, Part 1, for the three DC-MSS-IMT systems examined).

Table 7 reports, for the bounding system, System 3A, in each band and at each border location, the Largest I/N_{36th} at the limit, the number of Flight Tests Not Protected, the observed proportion, and the one-sided 99% Clopper-Pearson upper confidence bound on that proportion. Every independently evaluated geometry case is below the 0.5% criterion at the one-sided 99% confidence level. Acceptance is determined by that confidence bound rather than by requiring that no individual flight test suffer exceedances.

TABLE 7

AMT band	Location	Largest I/N _{36th} [dB]	Flight Tests Not protected	Observed [%]	99% CP upper [%]
1 435-1 525 MHz	Northern	-4.475	0/8 000	0.000	0.0575
1 435-1 525 MHz	Southern	-5.584	0/8 000	0.000	0.0575
1 780-1 850 MHz	Northern	-4.358	0/8 000	0.000	0.0575
1 780-1 850 MHz	Southern	-5.467	0/8 000	0.000	0.0575
2 360-2 395 MHz	Northern	-4.417	0/8 000	0.000	0.0575
2 360-2 395 MHz	Southern	-5.526	0/8 000	0.000	0.0575

4. Conclusion

At the emission levels found in Doc. 4C/744, Annex 10, System 3A, System 3B and System 4 each exceed the Rec. ITU-R M.1459 protection criteria at cross-border locations on both the northern and southern U.S. borders, for individual two-hour flight tests. At each time step the interference is dominated by the single nearest satellite to the AMT receiving station's boresight; the rest of the constellation, seen only through deep antenna sidelobes, contributes a bounded additional amount, no more than a maximum of 3.6 dB in any time step, which is included in the incoherent sum. Reducing the emission level in the AMT bands by the amount the Rec. ITU-R M.1459 criteria are exceeded yields an angle-independent protective pfd limit, applying at every angle of arrival (down to 20 degrees) and applicable universally, under which the proportion of 7 200-second flight tests not protected is bounded below 0.5% at the one-sided 99% confidence level. The resulting protective pfd limits for NGSO MSS providing DC-MSS-IMT on the surface of the earth to protect AMT, expressed as the aggregate pfd from all space stations of a DC-MSS-IMT system, in any 4 kHz band and for all methods of modulation, at arrival elevation angles between 20° and 90°, inclusive, are

- **Within the 1 435-1 525 MHz band: $-187.5 \text{ dB(W/(m}^2 \cdot 4 \text{ kHz))}$**
- **Within the 1 780-1 850 MHz band: $-186.0 \text{ dB(W/(m}^2 \cdot 4 \text{ kHz))}$**
- **Within the 2 360-2 395 MHz band: $-183.5 \text{ dB(W/(m}^2 \cdot 4 \text{ kHz))}$**

An independent set of validation simulations confirms the limit is sufficient to protect AMT operations and not more restrictive than necessary: every independently evaluated geometry case satisfies the Rec. ITU-R M.1459 criterion at the one-sided 99% confidence level (section 3, Table 7). Because the criterion is applied per flight test, meeting the limit protects each

individual safety-of-flight test mission, on which loss of real-time telemetry can jeopardize the test article, its pilots and crew, and persons on the ground.

Further study would be required if there were a need to derive an angle-dependent protective pfd limit applicable across the range of non-geostationary system architectures considered in this study. Similarly, further study would be necessary to confirm that the angle-independent pfd values derived herein would be protective if they applied below 20 degrees angle of arrival.

APPENDIX C

Proposed Addition to View A Draft New Resolution

(See new *resolves n bis*)

[...]

DRAFT NEW RESOLUTION

ADD **PP/1.13/7**

Supports: USA

DRAFT NEW RESOLUTION [DC-MSS-IMT] (WRC-27)

Use of the mobile-satellite service for direct connectivity between space stations and International Mobile Telecommunications (IMT) user equipment to complement/supplement terrestrial IMT network coverage

The World Radiocommunication Conference (Shanghai, 2027),

considering

- a) that International Mobile Telecommunications (IMT), including IMT-2000, IMT-Advanced, IMT-2020, and IMT-2030, is the ITU vision of global mobile access and accordingly it is important that technical or operational measures are implemented to avoid harmful interference to terrestrial IMT systems deployed in the same frequency band or adjacent frequency bands;
- b) that IMT systems provide telecommunication services on a worldwide scale regardless of location, network or terminal used;
- c) that the mobile satellite service (MSS), operating in mobile service (MS) bands identified for IMT, may provide network resilience and extend terrestrial IMT coverage in remote and hard to reach areas, as well as in the event of terrestrial IMT unavailability due to natural disasters or other emergency circumstances;
- d) that DC-MSS-IMT operations are capable of providing mobile connectivity directly from space to IMT terrestrial UEs, thereby complementing terrestrial IMT networks;

noting

- a) that the IMT user equipment (UE) that is part of the DC-MSS-IMT system is a terrestrial mobile terminal station that can support a variety of the frequency bands identified for IMT, and
- b) that operations of a DC-MSS-IMT system, for operations with terrestrial IMT UEs within the territory of any individual ITU administration, are subject to the authorization of that ITU administration;

resolves

- 1 that administrations planning to implement DC-MSS-IMT for operations with terrestrial IMT UEs in that administrations' territory, may make available for DC-MSS-IMT, based on national considerations, the frequency bands identified in 5.A113, 5.B113, 5.C113, 5.D113, 5.E113, 5.F113, 5.G113, and 5.H113 on a secondary basis, taking into account the services to which the frequency bands are currently allocated;
- 2 that new allocations to the MSS in frequency bands identified for IMT are limited to direct connectivity between MSS space stations and IMT user equipment;
- 3 that an IMT UE operating as part of a DC-MSS-IMT system shall operate with the same technical parameters for communications with MSS space stations as it does with terrestrial mobile IMT base stations;
- 4 that the notifying administration(s) for the MSS system or network associated with the DC-MSS-IMT system shall:

- a. ensure that the operations by MSS space stations in the frequency bands identified for DC-MSS-IMT are limited to communications with terrestrial IMT UEs;
- b. submit all mandatory elements of Appendix 4 information to the Radiocommunication Bureau, together with a commitment that the system's operations shall be in conformity with the Radio Regulations, including this resolution which is incorporated by reference into the Radio Regulations;
- c. ensure that the notified MSS system or network has the capability to cease transmissions as required to immediately address reported instances of harmful interference to services operating on a primary basis in the bands identified for DC-MSS-IMT or in adjacent bands, and commit to addressing those instances;
- d. include informationally, as associated with MSS frequency assignments in the MIFR, a list of the national territories where individual administrations have authorized the DC-MSS-IMT system for operations with terrestrial mobile stations within their respective territories, and update this information on an ongoing basis;
- e. for the purpose of protecting the mobile service, including IMT terrestrial systems in the territory of neighboring administrations, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD limits, per system, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s);
 - i) For the purpose of protecting terrestrial IMT networks operating in compatible FDD schemes, in the territory of neighboring administrations, the aggregate power flux density at the earth's surface produced by all visible beams and satellites within each satellite constellation providing DC-IMT-MSS service as they move over any given point or area must meet the following limits:

DC- MSS-IMT Frequency	738 (MHz)	880 (MHz)	1400 (MHz)	1900 (MHz)	2300 (MHz)	2500 (MHz)
Aggregate pfd limit (dBW/m²/MHz) for $0^\circ < \theta < 90^\circ$ where θ is the angle of arrival of the incident wave above the horizontal plane, in degrees	-122.019	-120.49	-116.458	-113.805	-112.146	-111.422

- ii) For the purpose of protecting terrestrial IMT networks operating in TDD schemes or non-compatible FDD schemes, in the territory of neighboring administrations, the aggregate power flux density at the earth's surface produced by all visible beams and satellites within each satellite constellation providing DC-IMT-MSS service as they move over any given point or area must meet the following limits:

For frequency bands below 1.4 GHz:

–142 dB (W/m²) in 1 MHz for all angles of arrival between 0 and 5 degrees above the horizontal plane

–142 dB (W/ m²) + 0.95(θ –5) in 1 MHz for all angles of arrival between 5 and 25 degrees above the horizontal plane

–123 dB (W/ m²) in 1 MHz and for all angles of arrival between 25 and 90 degrees above the horizontal plane

where θ is the angle of arrival of the incident wave above the horizontal plane, in degrees

For frequency bands between 1.4 GHz and 2.4 GHz:

–132 dB (W/m²) in 1 MHz for all angles of arrival between 0 and 5 degrees above the horizontal plane,

–132 dB (W/ m²) + 0.95(θ –5) in 1 MHz for all angles of arrival between 5 and 25 degrees above the horizontal plane

–115 dB (W/ m²) in 1 MHz and for all angles of arrival between 25 and 90 degrees above the horizontal plane

where θ is the angle of arrival of the incident wave above the horizontal plane, in degrees

For frequency bands above 2.4 GHz:

–126 dB (W/m²) in 1 MHz for all angles of arrival between 0 and 5 degrees above the horizontal plane

–126 dB (W/ m²) + 0.65(θ –5) in 1 MHz for all angles of arrival between 5 and 25 degrees above the horizontal plane

–113 dB (W/ m²) in 1 MHz and for all angles of arrival between 25 and 90 degrees above the horizontal plane

where θ is the angle of arrival of the incident wave above the horizontal plane, in degrees

- iii) For the purpose of protecting aeronautical mobile service (AMS) receivers, ensure that the aggregate power flux density at the earth's surface produced by all visible beams and satellites within each satellite constellation providing DC-IMT-MSS service as they move over any given point or area, as measured at the surface of the Earth in the territory of other administrations must meet the following limits, unless a different limit or other alternative is agreed upon through bilateral or

multilateral coordination with the relevant geographically neighboring or nearby administration(s):

[insert PFD limits TBD]

- f. for the purpose of protecting the fixed service (FS), ensure that operations of the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD limits, per system, as measured at the surface of the Earth in the territory of other administrations, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s):

[Insert bands]			
XXX	$dB(W/(m^2 \cdot MHz))$	for	$0^\circ < \theta \leq X^\circ$
XXX	$dB(W/(m^2 \cdot MHz))$	for	$X < \theta \leq Y^\circ$
XXX	$dB(W/(m^2 \cdot MHz))$	for	$Y < \theta \leq Z^\circ$

where θ is the angle of arrival of the incident wave above the horizontal plane, in degrees

- g. for the purpose of protecting the broadcasting service (BS), ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD limits, per system, at a height of 10 meters, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s):

[insert PFD limits TBD, insert bands]

- h. for the purpose of protecting the aeronautical-radionavigation service, ensure that the MSS space stations in the DC-MSS-IMT system are operating in accordance with the following limits, per system:

[TBD with relevant frequencies, specific limits]

- i. for the purpose of protecting MSS earth station receivers, ensure that the MSS space stations in the DC-MSS-IMT system are operating in accordance with the following aggregate PFD limits, per system, as measured at the surface of the Earth in the territory of the other administration, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s):

[insert PFD limits TBD with relevant frequencies]

- j. for the purpose of protecting EESS earth station receivers, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD limits, per system, as measured at the surface of the Earth in the territory of another administration, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s);

[PFD limits TBD with relevant frequencies]

- k. for the purpose of protecting SOS earth station receivers, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD limits, per system, as measured at the surface of the Earth in the territory of another administration, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s);

[PFD limits TBD with relevant frequencies]

- l. for the purpose of protecting SRS earth station receivers, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD limits, per system, as measured at the surface of the Earth in the territory of another administration, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s);

[PFD limits TBD]

- m. for the purpose of protecting radiolocation service systems, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with the following aggregate PFD unwanted emissions limits, per system, as measured at the surface of the Earth in the territory of another administration, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s);

[PFD limits TBD]

- n. relevant to stations of the radio astronomy service, ensure that the MSS space stations in the DC-MSS-IMT are operating in accordance with the following:

[TBD]

n bis. In Region 2, for the purpose of protecting aeronautical mobile telemetry receive stations, ensure that the MSS space stations in the DC-MSS-IMT systems are operating in accordance with a PFD limit of $-183.5 \text{ dB(W/(m}^2 \cdot 4\text{kHz))}$ applicable to the emissions from DC-MSS-IMT systems, per system, into the frequencies 2 360-2 395 MHz measured as the aggregate power flux-density by all space stations of a DC-MSS-IMT

system in any 4 kHz band and for all methods of modulation, at the surface of the Earth at any point within the territory of the neighboring administration at arrival elevation angles between 20° and 90°, inclusive, unless a different limit or other alternative is agreed upon through bilateral or multilateral coordination with the relevant geographically neighboring or nearby administration(s).

- o. cooperate with relevant administrations to verify compliance with PFD limits and any other regulatory limits applicable at the border between any administration authorizing the DC-MSS-IMT operations in its territory and other neighboring administrations;

5 that administrations wishing to implement DC-MSS-IMT within their national territory shall:

- a. notify frequency assignments for DC-MSS-IMT systems by submitting all mandatory elements of Appendix 4 to the Radiocommunication Bureau, for the examination of compliance with the conditions specified in this Resolution without any need for coordination under Section II of Article 9;
- b. ensure that the operations of the DC-MSS-IMT system are conducted pursuant to agreement between the MSS satellite network operator(s) or notifying administration(s) and the relevant terrestrial IMT mobile network operator(s) for the area in which the DC-MSS-IMT system will operate;
- c. ensure that the operations of the DC-MSS-IMT system are conducted in accordance with any country-specific, regional, or international IMT frequency arrangements (e.g., Frequency Division Duplex) as deployed by terrestrial IMT mobile network operators, namely the uplink and downlink directionality, including as specified by the Table of Frequency Allocations; and
- d. prior to national licensing, verify through technical assessment at each international border, that the DC-MSS-IMT system has the capability to meet the PFD limits for protection of MS in bordering countries as well as relevant limits for protection of other services.

invites administrations

1 to review the information provided in Annex [insert TBD] to this Resolution as further guidance for examples on how an individual administration may implement this Resolution in authorizing DC-MSS-IMT systems and verifying compliance with relevant regulatory limits; and

2 to review this Resolution and Annex [insert TBD] to this Resolution as guidance to help ensure cross-border compatibility to the extent the following mobile-satellite service allocations are used for provision of direct connectivity between space stations and terrestrial International Mobile Telecommunications (IMT) user equipment operating as part of a DC-MSS-IMT system:

- a) 806-840 MHz (Earth-to-space), 856-890 MHz (space-to-Earth) and 942-960 MHz under Nos. 5.317, 5.319 and 5.320;
 - b) 2 000-2010 MHz (Earth-to-space) and 2170-2200 (space-to-Earth)
 - c) 2 010-2025 MHz (Earth-to-space) and 2120-2170 (space-to-Earth) in Region 2.
- instructs the Director of the Radiocommunication Bureau*

to take all other necessary measures to implement this Resolution.

Reasons: These additional procedures and limitations in this Resolution are not in conflict with the domestic approach in the United States for SCS, and also ensure that information is available regarding the operations of DC-MSS-IMT systems internationally, address international concerns about operations being duly authorized, and set forth limits for protection of IMT and other incumbent services in the frequency bands identified for DC-MSS-IMT.