NATO STANDARD

AComP-5648

INTEROPERABILITY OF SUPERHIGH FREQUENCY (SHF) SATELLITE COMMUNICATIONS TERMINALS

Edition A, Version 1

MAY 2023

NORTH ATLANTIC TREATY ORGANIZATION
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NATO LETTER OF PROMULGATION

4 May 2023

1. The enclosed Allied Communications Publication AComP-5648, Edition A, Version 1, SUPER HIGH FREQUENCY (SHF) SATELLITE COMMUNICATIONS TERMINALS, which has been approved by the nations in the Consultation, Command, and Control Board (C3B), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 5648.

2. AComP-5648, Edition A, Version 1, is effective upon receipt.

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4. This publication shall be handled in accordance with C-M(2002)60.

Dimitrios SIGOULAKIS
Lieutenant General, GRC (A)
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

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RECORD OF SPECIFIC RESERVATIONS

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CHAPTER 1. SCOPE

1.1 Aim. This super high frequency (SHF) MILSATCOM interoperability standard for terminals operating in X-Band and military K_a-Band will provide NATO with the communications interoperability required to meet NATO net-centric SATCOM objectives. The aim of this agreement is to define the technical characteristics necessary for direct Radio Frequency (RF) interoperability among X-Band and military K_a-Band SHF satellite communications terminals. In addition, the aim is to define communications parameters that enable efficient transport of communications over transponded satellites while minimizing interference and ensuring efficient use of on-orbit resources. This standard will promote commonality among SATCOM earth terminal equipment which will provide for more effective interoperability among allied systems.

The contents of this AComP supersede the X-Band and military K_a-Band terminal performance requirements specified in STANAG 4484 Edition 3 which was promulgated on 5 March 2015. Future versions of STANAG 4484 will reference this AComP for X-Band and military K_a-Band terminal requirements.

1.2 Purpose. The purpose of this standard is to provide the performance requirements necessary to achieve interoperability between allied systems.

a. This standard provides the basis to achieve interoperable communications over existing non-processing transponders and future X-Band and military K_a-Band capable satellites.

b. This standard applies only to the satellite constellations specified in TABLE I. It is not intended as a specification for other constellations. Furthermore, this standard applies to geosynchronous satellites only.

c. This standard provides a pathway to achieve RF interoperability between ground fixed, ground transportable, ground mobile, airborne, and shipborne X-Band, and military K_a-Band SHF satellite terminals.

d. This standard sets forth performance requirements for system interoperability to aid mission planning activities. Introducing the use of different constellations, ensuring communications with other allied nations, and connectivity to the wide array of SATCOM terminals.

Due to the diversity of terminals, environments, and mission objectives it is not feasible to address any specific mission profile. It is the responsibility of the individual mission planning activity and/or related program office to use these performance specifications for communications as a part of their overall individual mission profile.

Equipment developers may exceed the requirements herein to satisfy specific program or mission requirements. Incorporating additional interfaces or other standard or nonstandard capabilities are allowed with the provision that interoperability is strictly maintained. As the performance requirements set forth in this document are limited to MILSATCOM interoperability only, this document is not to be construed as a replacement for, or the basis of, any type of procurement document, a specification intended for the use of a procurement document, or any other combination of the two. Equipment developers and procurement agencies are strongly encouraged to confer with the appropriate national satellite constellation payload authority (SCPA) for full details of the suite of requirements and artifacts necessary to procure terminals which can successfully receive approval for operation. See 6.2 for additional procurement information.

As this standard is an interoperability specification, procurement agencies are strongly cautioned against leveraging this standard in isolation.

1.3 Promulgation. This Allied Communications Publication (AComP) is promulgated by the Director of the NATO Standardization Organization under the authority vested by the NATO Military Committee.

a. No departure may be made from the agreement without consulting with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

b. Ratifying nations have agreed that national orders, specifications, manuals, and instructions implementing this AComP will include a reference to the AComP number for purposes of identification.

c. Compliance with this standard does not guarantee access to any satellite constellation and self-determination of compliance is unlikely to be sufficient for National SCPA approvals. This AComP does not supersede the authority of National SCPAs to implement performance verification processes and procedures specific to their constellation. Users must coordinate with SCPAs to obtain access approval.

d. For a terminal to be eligible for approval by a National SCPA to access their nation's constellation, the terminal must meet the performance requirements specified for that constellation including the constellation specific requirements of TABLE I and shared requirements of Sections 4 and 5.

1.4 Additional requirements. SCPAs may levy certification requirements in addition to the requirements listed herein so long as they do not contradict any conformance requirements listed in this document. Note that this document is not intended to provide information regarding how to achieve such additional requirements. Terminal designers/vendors should refer to applicable requirements and test procedures issued by SCPAs for each relevant constellation.

1.5 Claims of compliance with the standard. Equipment developers that claim compliance with this standard must state their compliance in the form of "Complaint with AComP 5648 for Constellation [x]", where "Constellation [x]" is one of the constellations documented in TABLE I. Specifically:

- A claim of "Compliant with AComP 5648 for Constellation [x]" may only be made if the ET meets all the shared requirements of sections 4.1 and 5.1 plus all requirements for Constellation X in TABLE I.

An equipment developer may claim compliance with this standard for more than one constellation if the statement above is true for each constellation claimed. For additional assistance in determining compliance, see section 6.8.

1.6 Deviation from the standard.

a. Earth Terminals (ETs) that deviate from this standard and are accepted by a national procuring agency without first obtaining approval for deviation from the appropriate SCPA are acquired at national program risk.

b. Special cases of general requirements are addressed in appendices for specific types of ETs, allowing the SCPA to issue a full ET authorization to operate for any ET that implements requirements as modified by that specific appendix. The national procuring agency, without approval from the SCPA, may instruct a manufacturer to replace a chapter 4 or chapter 5 section with the appropriate appendix section.

1.7 Document structure. The main body of this document addresses requirements applicable to all ETs, including stationary and on-the-move (OTM) ETs. Appendices addressing additional requirements, which replace specific requirements in the body of the document as described in 1.6b and are applicable to unique types of ETs, are categorized as follows:

a. Appendix A, Land-Based SATCOM OTM Earth Terminals.

b. Appendix B, Air-Based SATCOM OTM Earth Terminals.

c. Appendix C, Array-Based SATCOM OTM Earth Terminals.

d. Appendix D, Constellation Specific ESD Performance Limits.

CHAPTER 2. APPLICABLE DOCUMENTS

2.1 General. The following documents form a part of this standard to the extent specified herein. The document issue, unless otherwise specifically mentioned, shall be the latest in effect at the time of AComP promulgation. In the event of conflict between the documents referenced and the contents of this standard, the contents of this standard shall be considered the superseding requirement.

2.2 NATO publications. The following documents form a part of this document to the extent specified herein.

North Atlantic Treaty Organization

SRD 5648.1	-	STANAG Related Document (SRD), Test Procedures

(Copies of this document are available online at http://nso.nato.int.)

2.3 Non-NATO publications. The following documents form a part of this document to the extent specified herein.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	-	IEEE Standard for Ethernet

(Copies of this document are available online from https://www.ieee.org or from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854-4141.)

INTERNATIONAL TELECOMMUNICATIONS UNION (ITU)

Radio Regulations	-	Current applicable edition of ITU Radio Regulations.
Recommendation ITU-R S.524-9	-	Maximum permissible levels of off-axis e.i.r.p. density from earth stations in geostationary-satellite orbit networks operating in the fixed-satellite service transmitting in the 6 GHz, 13 GHz, 14 GHz, and 30 GHz frequency bands

Recommendation ITU-R S.580-6	-	Radiation diagrams for use as design objectives for antennas of earth stations operating with geostationary satellites
Recommendation ITU-R S.732-1	-	Method for statistical processing of earth station antenna side-lobe peaks to determine excess over antenna reference patterns and conditions for acceptability of any excess

(Copies of these documents are available online from https://www.itu.int/.)

2.4 Order of precedence. Unless otherwise noted herein, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

CHAPTER 3. DEFINITIONS

3.1 Definitions of terms. Definitions of terms not listed in this section are as defined in the ITU Terms and Definitions Database available at https://www.itu.int/.

3.2 Abbreviations. The abbreviations used in this MIL-STD are defined as follows.

AC	alternating current
AComP	Allied Communications Publication
CEVD	convolutional encoding and Viterbi decoding
CMA	control, monitor, and alarm
CW	continuous wave
D_e	equivalent antenna diameter
EIRP	effective isotropic radiated power
ESD	EIRP spectral density
ET	earth terminal
GNSS	Global Navigation Satellite System
GNSSDO	GNSS disciplined oscillator
GSO	geostationary orbit
G/T	gain-to-noise temperature ratio
HPA	high-power amplifier
IEEE	Institute of Electrical and Electronics Engineers
IF	intermediate frequency
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union Radio Communication Sector
LHCP	left-hand circular polarization
LNA	low-noise amplifier
MLP	Maximum linear power
NATO	North Atlantic Treaty Organization
OTM	on the move
PFD	power flux density
PM	Program Manager
PSD	power spectral density
PSK	phase-shift keying
QPSK	quadrature phase-shift keying
RF	radio frequency
RHCP	right-hand circular polarization
RMS	root mean square
R_S	symbol rate

RSL	received signal level
RSS	root sum square
SATCOM	satellite communications
SHF	Super high frequency
SNMP	Simple Network Management Protocol
SOW	statement of work
STANAG	standardization agreement
VSWR	voltage standing wave ratio
WGS	Wideband Global SATCOM
λ	wavelength

3.3 Antenna pointing. The action taken by the antenna control system to command the antenna's electrical boresight to a certain vector regardless of the antenna control system's method of determining the vector.

3.4 Antenna pointing loss. The antenna gain decrease due to the angular difference between the antenna boresight gain vector and the intended satellite target vector.

3.5 Antenna tracking. ET antenna tracking may be accomplished in either of two ways. In open-loop antenna tracking, the antenna is simply pointed in the direction of the satellite with the aid of positional, navigational, and perhaps platform motion data but without the aid of received signal level (RSL) data. Closed-loop antenna tracking may be accomplished with any of the aids used in open-loop antenna tracking, and with the addition of RSL data.

3.6 dBc. Ratio of a non-carrier power component to the total power in a carrier, expressed in decibels (dB).

3.7 dBi. Gain, in decibels, relative to an isotropic antenna.

3.8 dBm. Decibel relative to 1 mW.

3.9 dBW. Decibel relative to 1 W.

3.10 Earth terminal (ET). The portion of a satellite system that transmits and receives RF signals to and from a satellite. The ET is delimited by the intermediate frequency (IF) interface to the modem and the RF interface including radome (if used). All ET and antenna specifications must be met with radome performance included. For some requirements, modem functionality is included.

3.11 Effective isotropically radiated power (EIRP). The product of the power accepted by an antenna and its gain relative to a hypothetical antenna that radiates or receives equally in all directions.

3.12 EIRP spectral density (ESD). ESD is calculated as EIRP/symbol rate (R_s).

3.13 Equivalent diameter. For non-circular apertures, the equivalent diameter (D_e), shown on FIGURE 1, may be computed by:

$$D_{\mathrm{e}} = 2\sqrt{A/\pi}$$

Where:
A = aperture area.

For electronically scanned antennas, the equivalent diameter (D_e) may be computed by:

$$D_{\mathrm{e}} = 2\sqrt{A/\pi}\cos\psi$$

Where:
A = aperture area.
ψ = the electronic scan angle

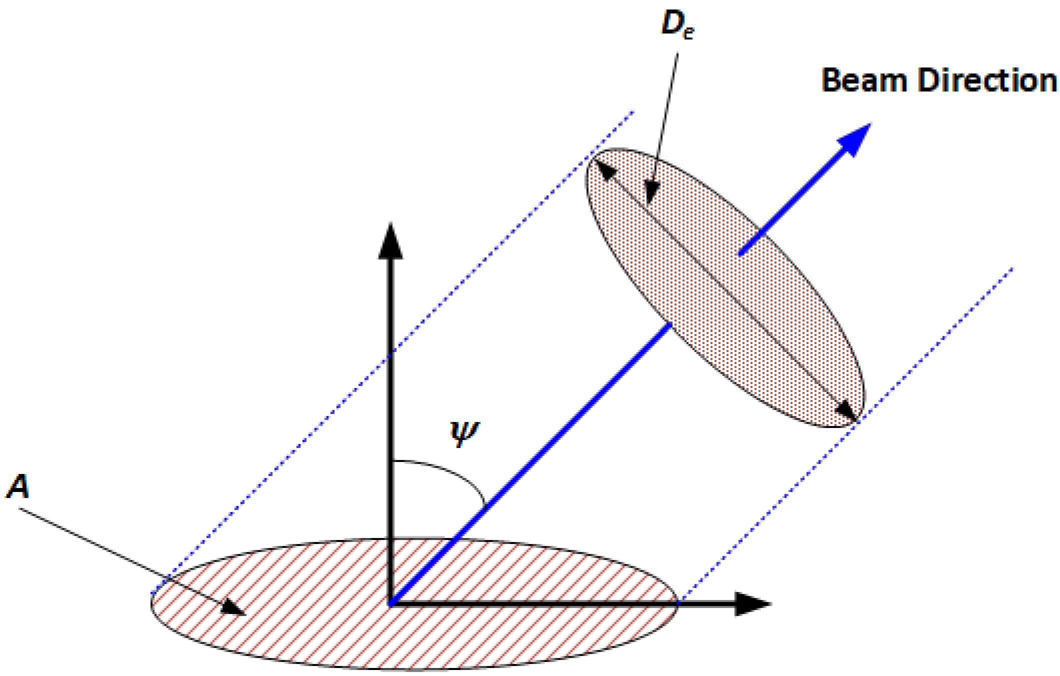


FIGURE 1. Equivalent diameter for electronically scanned antennas.

3.14 External frequency reference. Any frequency reference not part of the defined terminal system configuration.

3.15 Extraneous emissions. Emissions that result from spurious tones, bands of noise, transmit (uplink) RF harmonics, or other undesirable signals; intermodulation products are excluded.

3.16 *Gain-to-noise temperature ratio (G/T)*. *G*/*T* is the receive antenna gain-to-noise temperature ratio in dBi/K. Minimum *G*/*T* is measured while operating with the transmitter in a clear-sky condition, at the lowest frequency in the band, at a 10° elevation angle, and at 23 °C. G/T includes the entire reception function contributions.

3.17 Harmonics. A harmonic is a component frequency of the signal that is an integer multiple of the fundamental frequency.

3.18 Instantaneous bandwidth. The range over which a system's passband amplitude and phase response vs. frequency remain compliant without any tuning; compliance is governed by 4.2.7, 4.2.8, 4.3.6, and 4.3.7.

3.19 Internal frequency reference. Any frequency reference part of the defined terminal configuration which includes not only local oscillators but also standalone reference sources.

3.20 IF input. The first point of physical connection after the modulator output.

3.21 IF output. The last point of physical connection before the demodulator input.

3.22 Maximum linear power. For ETs with a single carrier, the definition is as stated in 3.22.1. For an ET capable of supporting multiple carriers, maximum linear power is defined in 3.22.1 or 3.22.2, whichever yields the lesser value.

3.22.1 Single carrier maximum linear power. The carrier power where the first spectral regrowth side lobe (measured at 1.0 symbol rate, expressed in Hz from the carrier center frequency) of the modulated carrier is -30 dBc.

3.22.2 Two carrier maximum linear power. The maximum combined transmit power of two equal-amplitude continuous wave (CW) carriers, when any individual intermodulation product power is –25 dB relative to the combined power of the two CW carriers.

3.23 Reception function. The reception function receives RF signals from a satellite, provides low-noise amplification, and down-converts the RF signal to an IF signal. The reception function includes all the equipment from the RF input (including radome, if used) to the IF output.

3.24 Satellite constellation payload authority. The satellite constellation payload authority (SCPA) is the approval authority responsible for managing the user traffic and allowable Earth Terminal configurations on a given satellite communications payload or family of payloads.

3.25 Satellite system. A communications system that includes two or more ETs, a communications satellite or a space platform, and a control system.

3.26 Saturated power. The single carrier output power level of an active device where the ratio of input power change to output power change is 10:1.

3.27 Transmission function. The transmission function up-converts the IF signal to a RF signal, amplifies the RF signal, and transmits the RF signal to a satellite. The transmission function includes all of the equipment from the IF input to the RF output, including radome (if used).

3.28 Variable Performance Terminal. Any terminal that exhibits variations in EIRP, G/T, off-axis ESD, or axial ratio as a function of its main beam pointing angle and are identified as terminals with non-symmetric radomes or electronically-steerable-beam antennas.

CHAPTER 4. GENERAL REQUIREMENTS

4.1 General. Unless a specific band is identified in a subsection, each subsection in this section applies to all bands of operation. Some requirements in this section have constellation specific limits as shown in TABLE I.

TABLE I. Terminal performance limits by constellation

Req ID	Requirement	Paragraph	SPAINSAT-NG	COMSATBw	SICRAL	Syracuse	WGS	Skynet
1	TX Thermal Noise	4.2.12	5 dBm/Hz maximum EIRP spectral density at MLP		-5.0 dBm/Hz EIRP spectral density with IF input terminated	5 dBm/Hz EIRP spectral density at MLP	-75.0 dBm/Hz maximum when measured at antenna feed with IF input terminated	
2	Intermodulation Products in RX band	4.2.16	No greater than -135.0 dBm at LNA input for two TX carriers, any TX frequency, each carrier EIRP 3.0 dB less than MLP				PSD of any intermodulation product at least 17.0 dB below the noise PSD	
3	Maximum PFD, X-Band	4.3.2	-142.0 dBW/m^2 in any 4.0 kHz band (Note 1)		-142.0 dBW/m^2 in any 4.0 kHz band -95.0 dBW/m^2 across the entire 500 MHz band			
4	Maximum PFD, Ka-Band	4.3.2	-115.0 dBW/m^2 in any 1.0 MHz band (Note 1)	Not Applicable	-115.0 dBW/m^2 in any 1.0 MHz band -92.0 dBW/m^2 across entire 1.0 GHz band	-115.0 dBW/m^2 in any 1.0 MHz band -93.0 dBW/m^2 across entire 1.0 GHz band	-112.0 dBW/m^2 in any 1.0 MHz band in any single carrier -90.0 dBW/m^2 across entire 1.0 GHz band	

<table>
<tr><th>Req ID</th><th>Requirement</th><th>Paragraph</th><th>SPAINSAT-NG</th><th>COMSATBw</th><th>SICRAL</th><th>Syracuse</th><th>WGS</th><th>Skynet</th></tr>
<tr><td>5</td><td>RX Spurious Output: Continuous Component</td><td>4.3.9.1</td><td>At least 20 dB below thermal noise power measured within the narrowest band of interest</td><td>At least 20 dB below thermal noise power measured across a bandwidth of:
36 MHz for a 70 MHz IF
72 MHz for a 140 MHz IF
120 MHz for an L-Band IF</td><td rowspan="2">The combined power of the continuous and discrete spurious output components shall be at least 20 dB below the thermal noise power measured across a bandwidth of:

• 36 MHz for a 70 MHz IF
• 72 MHz for a 140 MHz IF
• 120 MHz for an L-band IF

Also, the combined power of the continuous and discrete spurious output components shall be at least 10 dB below the thermal noise power within the narrowest bandwidth of interest.</td><td colspan="3">Spurious signal power within the narrowest band of interest, at least 10.0 dB below the thermal noise power within that narrowest band of interest</td></tr>
<tr><td>6</td><td>RX Spurious Output: Discrete Component</td><td>4.3.9.2</td><td colspan="2">At least 10 dB below thermal noise power within narrowest band of interest</td><td colspan="3">At least 20 dB below thermal noise power within narrowest band of interest</td></tr>
</table>

Req ID	Requirement	Paragraph	SPAINSAT-NG	COMSATBw	SICRAL	Syracuse	WGS	Skynet
7	Antenna Pointing Loss	4.3.12	0.8 dB for systems employing tracking and 1.0 dB for systems without tracking. For maximum operational wind velocities, the pointing loss shall not exceed 2.0 dB for both tracking and non-tracking systems.		0.8 dB, 99.7 percent of the time, sampled every 10 seconds and smoothed with a 10-point moving average for systems employing tracking and 1.0 dB for systems without tracking. For maximum operational wind velocities, the pointing loss shall not exceed 2.0 dB for both tracking and non-tracking systems.	0.8 dB for systems employing tracking and 1.0 dB for systems without tracking. For maximum operational wind velocities, the pointing loss shall not exceed 2.0 dB for both tracking and non-tracking systems.	0.8 dB, 99.7% of the time, sampled every 10 seconds, smoothed with a 10-point moving average	
8	ESD, K_a-Band	4.4.1.2	Appx D, Para D.5.1	Not Applicable	Appx D, Para D.5.1	Appx D, Para D.4.1	Appx D, Para D.5.1	
9	Antenna Polarization: K_a-Band, TX & RX	4.4.2	TX: RHCP RX: LHCP	Not Applicable	TX and RX: RHCP (clockwise) and LHCP (counterclockwise). However, military Ka-band ETs are not required to operate with simultaneous transmit of RHCP and LHCP, or simultaneous receive of LHCP and RHCP.			
10	Axial Ratio: K_a-Band, TX & RX	4.4.3	TX & RX: 1.0 dB maximum	Not Applicable	TX: 1.0 dB maximum RX: 1.5 dB maximum			

Req ID	Requirement	Paragraph	SPAINSAT-NG	COMSATBw	SICRAL	Syracuse	WGS	Skynet
11	ESD, X-Band	4.5.1.2	Appx D, Para D.5.2	Appx D, Para D.6.2	Appx D, Para D.5.2	Appx D, Para D.4.2	Appx D, Para D.5.2	
12	Antenna Polarization: X-Band, TX & RX	4.5.2	TX on both RHCP & LHCP RX on both LHCP & RHCP	Required: TX: RHCP RX: LHCP May also support: TX: LHCP RX: RHCP	TX: RHCP RX: LHCP			
13	Axial Ratio: X-Band, TX & RX	4.5.3	TX & RX: 1.0 dB maximum	TX & RX: 2.0 dB maximum with 1.0 dB recommended for operation on dual-polarization satellites	TX & RX: 2.0 dB Maximum			
14	System Implementation Loss	4.7	Not Applicable				Less than 2.0 dB	

Note 1: Consult SCPA for PFD requirements across the entire band.

4.2 Transmission function. The transmission function shall perform in accordance with 4.2.1–4.2.19.

4.2.1 Transmit chain alignment. Separate transmit alignment and carrier power control functions shall be provided for the purpose of transmit chain gain alignment and operational carrier EIRP control, respectively. These functions shall be independently controlled, either in hardware (physically separate functions) or in software (independent user inputs).

4.2.1.1 IF input level. With a single 0-dBm signal applied to any IF input, the transmit chain gain shall be sufficient to achieve maximum linear EIRP.

(NOTE: Procuring agencies for multi-carrier terminals may request deviation from this requirement from the SCPAs.)

4.2.2 RF frequency bands. The transmission function shall be tunable in one or more of the SHF frequency bands listed in TABLE II.

TABLE II. Transmit allocated frequency ranges

SHF Frequency Band	Frequency (GHz)
X-band	7.900–8.400
Military K_a-band	30.000–31.000

4.2.3 Tuning. The up-conversion function shall be tunable in increments not greater than 1-kHz, in conjunction with the modem, starting at the lowest frequency for each band, as listed in TABLE II. The instantaneous bandwidth shall be available at any tuned uplink frequency in TABLE II, as long as the instantaneous bandwidth does not extend beyond the band edges.

4.2.4 EIRP stability. For any setting of the transmit gain (see 5.3.1) and a constant IF input level, the EIRP in the direction of the satellite shall not vary more than 2.5 dB peak to peak in any 24-h period. This tolerance, added on a root sum square (RSS) basis, includes all ET factors contributing to the EIRP variation, including output power level instability and power variations due to pointing losses. See 6.5–6.7 for RSS theory and determination of power variations due to pointing losses. The formula for RSS error is

$$\sqrt{P_1^2 + P_2^2}$$

Where:

P_1 = transmission function output power level instability in dB.
P_2 = uplink power variations, in dB, in the direction of the satellite caused by pointing losses as described in 4.3.12 and 6.7.

For multi-band simultaneous operation, the variable P_2 shall be evaluated in the highest operational RF band.

4.2.5 Carrier frequency accuracy and stability. The radiated carrier frequency accuracy shall be within 1 kHz of the intended value for all RF carriers. The radiated carrier frequency accuracy shall be maintained for a 90-day period or more without recalibration.

4.2.6 Carrier power control accuracy, step size, and range. The absolute accuracy of the carrier power control attenuator(s) shall be within 1 dB of the selected attenuator value. The relative accuracy associated with the smallest step increment shall be within 0.1 dB. The minimum step size shall not exceed 0.25 dB. The minimum carrier power control range shall be sufficient to attenuate the signal from maximum linear EIRP to 60 dBm EIRP as given by the following equation:

Minimum range (dB) = Maximum linear EIRP (dBm) − 60 (dBm)

The power control range can be met by using a combination of the ET and modem power adjustments. When a carrier power change is initiated, the controlled carrier's power shall transition monotonically and shall not induce burst errors into the controlled carrier's bit stream or into the adjacent carrier's bit stream (with the adjacent carrier spaced at 1.2 R_S).

4.2.7 Transmit phase linearity. Departure from phase linearity of the transmission function, when operating at any point up to the maximum linear power, shall not exceed the following:

a. ±0.2 radian or less over any 2 MHz of instantaneous bandwidth.

b. ±0.4 radian over any 36 MHz of instantaneous bandwidth.

c. ±0.5 radian over any 72 MHz of instantaneous bandwidth.

d. ±0.6 radian over any 90 MHz of instantaneous bandwidth.

e. ±0.7 radian over any 120 MHz of instantaneous bandwidth.

4.2.8 Transmit amplitude response. Amplitude variations of the transmit (uplink) function when operating at maximum linear power shall not exceed the following:

a. ±0.5 dB over any 10-MHz segment across the instantaneous bandwidth.

b. ±1.5 dB over any 120-MHz segment, or any smaller segment, across the instantaneous bandwidth (10 MHz < segment < 120 MHz).

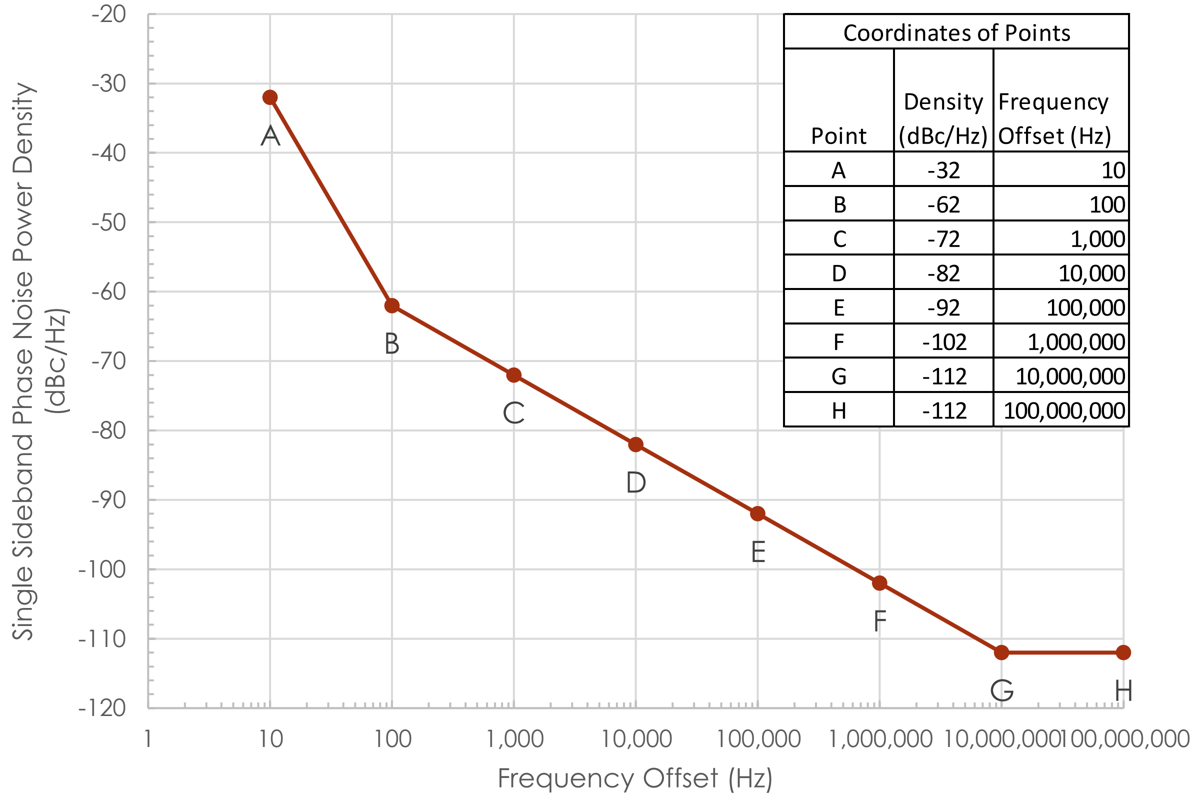
c. ±2.0 dB for each output frequency band listed in TABLE II.

4.2.9 Alternating current power line. The sum of the fundamental and all harmonic components of the alternating current (AC) line frequency shall not exceed −30 dBc.

4.2.10 Single sideband. The single sideband sum (added on a power basis) of all other individual spurious components shall not exceed −36 dBc.

4.2.11 Phase noise. The single sideband power spectral density (PSD) of the continuous phase noise component shall comply with the envelope defined in FIGURE 2. If specific points associated with the measured phase noise plot exceed the FIGURE 2 envelope, then the following two conditions shall be met:

a. The single sideband phase noise due to the continuous component, when integrated over the bandwidth from 10 Hz to 16 kHz relative to carrier center frequency, shall be less than 3.4° root mean square (RMS) (with a two-sided value of 4.8° RMS).



Coordinates of Points		
Point	Density (dBc/Hz)	Frequency Offset (Hz)
A	-32	10
B	-62	100
C	-72	1,000
D	-82	10,000
E	-92	100,000
F	-102	1,000,000
G	-112	10,000,000
H	-112	100,000,000

FIGURE 2. ET phase noise

b. The single sideband phase noise due to the continuous component, when integrated over the bandwidth from 1 percent of the symbol rate (R_S) to R_S Hz relative to the carrier center frequency, shall be less than the value obtained when integrating the FIGURE 2 plot over the same limits. This requirement shall be verified at the lowest and highest symbol rates. This requirement applies to all operational R_S values.

4.2.12 Transmit thermal noise. With the transmission function aligned according to 4.2.1, and power control set to achieve maximum linear power, the transmit thermal noise spectral density shall not exceed the limit specified in TABLE I.

4.2.13 Transmission function extraneous outputs. With the transmit equipment aligned and a CW signal applied to the IF input such that maximum linear power is achieved, or with the array configured to radiate maximum linear power and a CW signal applied to the IF input, extraneous emissions as measured over any 10-kHz bandwidth shall not exceed the following values:

a. Transmit band: −60 dBc when measured at the feed. This requirement excludes a 2-MHz band centered on the carrier.

b. Non-transmit band: −60.0 dBc, except for the band 31.0 GHz ≤ f ≤ 33.0 GHz, which shall not be greater than −45.0 dBc at 31.0 GHz and shall decrease linearly to −60 dBc by 33.0 GHz.

4.2.14 Harmonic emissions. The level of all harmonics of the transmit carriers shall not exceed −60 dBc when measured at maximum linear power.

4.2.15 Transmit-to-receive isolation. Transmit-to-receive isolation shall be such that there is less than a 0.1-dB increase, and no decrease, in receive noise density over the applicable frequency range shown in TABLE III with the transmitter operating at any EIRP level, compared to the receive performance with the transmitter turned off.

TABLE III. Receive allocated frequency ranges

SHF Frequency Band	Frequency (GHz)
X-band	7.250–7.750
Military K_a-band	20.200–21.200

4.2.16 Intermodulation products in the receive band. When transmitting two or more modulated carriers (in any bandwidth) with the aggregate at maximum linear power, intermodulation products at the IF output shall be as specified in TABLE I. A test procedure for verifying this requirement is provided in SRD 5648.1.

4.2.17 Transmit spectrum inversion. No spectral inversion shall exist between any IF input and the antenna output for ETs operating with non-embedded modems. ETs with embedded modems shall be interoperable with ETs that do not have embedded modems.

4.2.18 Input impedance. The IF interfaces shall have a nominal impedance of 50 Ω. The voltage standing-wave ratio (VSWR) over the IF band shall be less than 1.5:1 for IF band center frequencies below 1 GHz and 2.0:1 for IF band center frequencies above 1 GHz.

4.2.19 Transmit IF frequency. The IF input interface shall support one or more of the following frequency ranges below. Phase linearity requirements in 4.2.7 and the amplitude response requirements in 4.2.8 shall be met across the bandwidths below.

a. 950 to 2000 MHz (Limited to the required bandwidth as listed in TABLE II.)

b. 70 ± 18 MHz

c. 140 ± 36 MHz

d. 700 ± 62.5 MHz

4.3 Reception function. The reception function shall be in accordance with 4.3.1-4.3.13.

4.3.1 RF frequency bands. The down-conversion function shall be tunable in one or more of the SHF frequency bands listed in TABLE III.

4.3.2 Maximum power flux densities (PFDs). All reception functions shall be met with the maximum PFDs as specified in TABLE I.

4.3.3 Receive chain gain, linearity, and IF interface characteristics. The receive chain (antenna feed output interface to ET IF interface) shall exhibit the following characteristics:

4.3.3.1 Receive Chain Absolute Gain. When pointing to a cold sky at an elevation angle of not less than 30°, the receive chain absolute gain shall be sufficient to raise the IF output noise PSD to a minimum of −113 dBm/Hz.

4.3.3.2 Reception function Intermodulation Products. The PSD of any intermodulation product at the IF output shall be at least 17 dB below the noise PSD at any power and bandwidth combination equivalent to the antenna receiving the maximum power flux density per carrier bandwidth, and up to the maximum aggregate power flux density, both as given in 4.3.2. A test procedure for verifying this requirement is provided in SRD 5648.1.

4.3.3.3 IF Output Level Adjustment. When ET is pointed to an operational satellite, the receive chain absolute gain may be reduced to assist in complying with the linearity requirement described in 4.3.3.2, provided that the minimum IF output noise power spectral density described in 4.3.3.1 continues to be met. Any increase in system noise due to a reduction in receive chain absolute gain shall be incorporated into the terminal's G/T.

4.3.3.4 Output Impedance. The IF interfaces shall have a nominal impedance of 50 Ω. The voltage standing-wave ratio (VSWR) over the IF band shall be less than 1.5:1 for IF band center frequencies below 1 GHz and 2.0:1 for IF band center frequencies above 1 GHz.

4.3.4 Tuning. The down-conversion function shall be tunable in increments not greater than 1.0-kHz, in conjunction with the modem, starting at the lowest frequency for each band as listed in TABLE III. The instantaneous bandwidth shall be available at any tuned receive (downlink) frequency within the ranges listed in TABLE III.

4.3.5 Receive conversion frequency accuracy. The down-conversion frequency accuracy shall be within 1 kHz of the intended value for all received RF carriers. Down-conversion frequency accuracy shall be maintained for a 90-day period or more without recalibration.

4.3.6 Receive phase linearity. The RF-to-IF phase response of the reception function shall not deviate from linear by more than the following amounts:

a. ±0.2 radian over any 2-MHz segment across the instantaneous bandwidth.

b. ±0.4 radian over any 36-MHz segment across the instantaneous bandwidth.

c. ±0.5 radian over any 72-MHz segment across the instantaneous bandwidth.

d. ±0.6 radian over any 90-MHz segment across the instantaneous bandwidth.

e. ±0.7 radian over any 120-MHz segment across the instantaneous bandwidth.

4.3.7 Receive amplitude response. Amplitude variations as measured at the ET IF output (demodulator input) shall not exceed the following:

a. ±0.5 dB over any 10-MHz segment across the instantaneous bandwidth.

b. ±1.5 dB over any 120-MHz segment or smaller segment across the instantaneous bandwidth (10 MHz < segment < 120 MHz).

c. ±2.0 dB for each output frequency band listed in TABLE III.

4.3.8 Receive phase noise. The reception function shall meet phase noise requirements as defined in 4.2.11 and 4.3.9.

4.3.9 Receive spurious output.

4.3.9.1 Continuous component. The sum of all spurious signal power shall be as specified in TABLE I, when measured across the terminal IF output interface.

4.3.9.2 Discrete component. No one spurious signal shall exceed the level specified in TABLE I, when measured across the terminal IF output interface.

4.3.9.3 Component conditions. Both 4.3.9.1 and 4.3.9.2 above shall be met under the following simultaneous conditions:

a. Transmitting a single CW carrier at maximum-linear power.

b. Receiving one CW carrier at any frequency over the receive band, with a level equivalent to the antenna receiving the aggregate maximum power flux density given in 4.3.2.

The narrowest bandwidth of interest shall be 64kHz unless ET procurement documents specify a bandwidth less than 64kHz.

4.3.10 Receive spectrum inversions. No spectral inversion shall exist between any RF input and the IF output of the ET.

4.3.11 Receive signal level stability. For any setting of the receive gain and for a constant PSD level, the reception function output level shall not vary more than ±2.0 dB in any 24-h period.

4.3.12 Antenna pointing loss. The downlink loss due to antenna pointing error shall not exceed the limit specified in TABLE I. The loss shall be translated to the appropriate uplink loss in accordance with 6.7 and shall be used as the P_2 RSS contribution to the EIRP stability and accuracy specification in 4.2.4; P_2 is defined as the power variation in the direction of the satellite caused by pointing loss. This requirement shall be met under operational conditions with no blockage or keyhole events. A test procedure for verifying this requirement is provided in SRD 5648.1.

(NOTE: The ET procurement documents will provide guidance on wind speeds, and any other expected environmental conditions over which the ET is required to operate. Validation of specific pointing requirements will be performed by the procuring agency.)

4.3.13 Receive IF frequency. The IF output interface shall support one or more of the following frequency ranges below. Phase linearity requirements in 4.3.6 and the amplitude response requirements in 4.3.7 shall be met across the bandwidths below.

a. 950 to 2000 MHz (Limited to the required bandwidth as listed in TABLE III.)

b. 70 ± 18 MHz

c. 140 ± 36 MHz

d. 700 ± 62.5 MHz

4.4 Military K_a-band antenna requirements.

4.4.1 Antenna side-lobe levels and transmit ESD. The antenna side-lobe and ESD requirements are described in 4.4.1.1 and 4.4.1.2.

4.4.1.1 Equivalent diameter to wavelength ratio (D_e/λ) ≥ 50. The radiation pattern of the antenna while both transmitting and receiving, including radome effects, in the geostationary orbit (GSO) plane, shall be in accordance with Recommendation ITU-R S.580-6. Recommendation ITU-R S.732-1 shall be used for statistical processing of earth station antenna side-lobe peaks to determine excess over the antenna reference pattern and conditions for acceptability of any excess. Computation of wavelength (λ) will use 30.0 GHz and 20.2 GHz as the reference transmit and receive frequencies, respectively. For reference, the mask from Recommendation ITU-R S.580-6 is outlined below:

a. $G(\theta) = 29-25 \log_{10} \theta$ (dBi) for 1° or $100\ \lambda/D_e$ °
(Whichever is larger, up to $2° \leq \theta < 20°$)

b. $G(\theta) = -3.5$ (dBi) for $20° \leq \theta \leq 26.3°$

c. $G(\theta) = 32-25 \log_{10} \theta$ (dBi), for $26.3° < \theta < 48°$

d. $G(\theta) = -10$ (dBi), for $48° \leq \theta \leq 180°$

Where:

G = gain relative to an isotropic antenna

θ = the off-axis angle in the direction of the GSO plane referred to the main-lobe axis

D_e = equivalent antenna diameter

For reference, the angular regions and side-lobe peak allowed excess from Recommendation ITU-R S.732-1 are outlined below:

a. 1 dB for $\theta_{min} < \theta \leq 7°$, where θ_{min} = 1° or (100λ/De) degrees, whichever is greater

b. 3 dB for $7° < \theta \leq 9.2°$

c. 3 dB for $9.2° < \theta \leq 48°$

d. 10 dB for $48° < \theta \leq 180°$

(NOTE: Receive off-axis gain excursions may be considered allowable if it can be shown that relaxation of the off-axis gain results in improvement of the main beam gain.)

4.4.1.2 EIRP spectral density. For all ETs, ESD in the GSO plane shall not exceed the constellation specific limits specified in TABLE I.

4.4.2 Transmit and receive antenna polarization. The antenna shall be capable of operations specified in TABLE I.

4.4.3 Transmit and receive antenna axial ratio. The military K_a-band transmit and receive axial ratio shall be no greater than the limit specified in TABLE I.

4.5 X-band antenna requirements.

4.5.1 Antenna side-lobe levels and transmit ESD. The antenna side-lobe and ESD requirements are described in 4.5.1.1 and 4.5.1.2.

4.5.1.1 Equivalent diameter to wavelength ratio (D_e/λ) ≥ 50. The radiation pattern of the antenna while both transmitting and receiving, including radome effects, in the GSO plane shall be in accordance with Recommendation ITU-R S.580-6. Recommendation ITU-R S.732-1 shall be used for statistical processing of earth station antenna side-lobe peaks to determine excess over the antenna reference pattern and conditions for acceptability of any excess. Computation of λ will use 7900 MHz and 7250 MHz as the reference transmit and receive frequencies, respectively. The mask, angular regions, and side-lobe peak allowed excess are summarized for reference in 4.4.1.1.

(NOTE: Receive off-axis gain excursions may be considered allowable if it can be shown that relaxation of the off-axis gain results in improvement of the main beam gain.)

4.5.1.2 ESD. For all ETs, ESD in the GSO plane shall not exceed the constellation specific limits specified in TABLE I.

4.5.2 Transmit and receive antenna polarization. The antenna shall be capable of operations specified in TABLE I.

4.5.3 Transmit and receive antenna axial ratio. The X-band transmit and receive axial ratio shall be no greater than the limit specified in TABLE I.

4.6 Frequency references. If an ET is capable of accepting an external frequency reference, the ET shall accept an external frequency reference signal as follows:

a. Signal type: sinusoidal.

b. Frequency: either 5 MHz or 10 MHz, at least one or the other.

c. Input impedance: 50 Ω (nominal).

d. Input signal level: +6 to +16 dBm.

e. Maximum VSWR: 1.5:1.

Terminals shall include an internal frequency reference for accuracy and stability when an external frequency reference signal is not present.

4.6.1 GNSS disciplined oscillator (GNSSDO). For an external frequency reference that is GNSS dependent, such as a GNSSDO, the following requirements shall apply.

4.6.1.1 Frequency stability. The long-term final RF frequency stability drift shall not be greater than 1 kHz in a 90-day span regardless of the presence of a GNSS-aided signal and regardless of calibration.

4.6.1.2 Allan deviation. The stability of the 10- or 5-MHz reference source shall have the Allan deviations shown in TABLE IV under the conditions listed in 4.6.1.2.1−4.6.1.2.3:

TABLE IV. Allan deviation.

Time (s)	Allan Deviation
1	<1.5E−11
10	<1.5E−11
100	<1.5E−11
1000	<1.5E−11

4.6.1.2.1 GNSS Conditions. These Allan deviation values shall be met with and without a GNSS-aided signal.

4.6.1.2.2 GNSS receiver cold start procedure. On initial GNSS receiver turn-on (cold start) with the GNSS antenna disconnected; then connect the antenna within one hour. Connect the antenna and allow the GNSS receiver to warm up for at least one hour; then, remeasure the stability of the external frequency reference that is GNSS dependent. The frequency stability shall be no worse than allowed in TABLE IV.

4.6.1.2.3 Vibration and shock. Under full vibration, temperature shock, and shock as defined in 5.2, the frequency stability shall be no worse than allowed in TABLE IV.

4.7 System implementation loss. Total implementation loss shall be as shown in TABLE I for all modem operational parameters measured when operating in satellite loop-back. The reference used to determine implementation loss is the theoretical modem E_b/N_0 performance using a modem with quadrature phase-shift keying (QPSK) modulation, 1/2-rate convolutional encoding and Viterbi decoding (CEVD), randomizer on, and differential encoding/decoding on. Implementation loss includes the effects of traversing the ET uplink and downlink equipment, as well as the satellite. This shall be tested at low, middle, and high operational data rates.

4.8 Variable Performance Terminals. Variable performance terminals shall provide functionality to automatically control transmit power level and operation to limit the magnitude of variations in EIRP, G/T, off-axis ESD, and axial ratio, which are caused by beam pointing relative to the terminal platform. Procuring agencies for variable performance terminals may request deviation from this requirement from the relevant SCPAs.

CHAPTER 5. ADDITIONAL REQUIREMENTS

5.1 General. Unless a specific band is identified in a subsection, each subsection in this section applies to all bands of operation.

5.2 Phase perturbation. The transmission function shall not change the linear phase of the output RF signal by more than 20° in 0.2 s, and the reception function shall not change the linear phase of the input RF signal by more than 20° in 0.2 s, over the range of environmental conditions over which the ET is required to operate. This shall include as a minimum:

a. Exposure to temperature deviation.

b. Exposure to vibration.

c. Exposure to shock on the outside surface of the ET, simulating maintenance, operator, or other external action on the ET.

(NOTE: The ET procurement documents will provide guidance on the temperature range and rate of change, the vibration frequencies and accelerations, and any other expected environmental conditions over which the ET is required to operate.)

5.3 ET control and monitoring function. The ET shall meet the following requirements.

5.3.1 Control and monitoring parameters. As a minimum, remote and local control, monitor, and alarm (CMA) shall be provided in accordance with TABLE V. For all ET types, the composite and individual transmit carrier power shall be measured at the antenna feed for monitoring and reporting antenna feed power and EIRP. Antenna feed power may be computed from measured high-power amplifier (HPA) output power.

5.3.1.1 Transmit gain. The transmit gain, as computed, shall be within 2 dB of actual gain, neglecting any frequency dependencies in accordance with 4.2.8. Transmit gain is computed by adding:

a. The up-conversion function gain.

b. The gain/loss from the up-conversion function output to the power amplifier input.

c. The power amplifier gain.

d. Transmit loss to the antenna feed.

5.3.1.2 Receive gain. The receive gain, as computed, shall be within 5 dB of actual gain. Receive gain is computed by adding:

a. The gain from the LNA input to the down-conversion function.

b. The down-conversion function gain.

5.3.2 Control response times. The ET shall meet a response time of 0.5 s for all parameters in TABLE V.

5.3.3 ET remote control and monitoring interface. The ET remote control and monitoring interface shall be implemented as an IEEE 802.3-compliant Ethernet. The interface protocol shall be via the industry standard Simple Network Management Protocol (SNMP).

TABLE V. ET control and monitoring parameters

Control	Monitoring
Transmit gain of each up-conversion function	Transmit gain setting of each up-conversion function
Frequency setting of each up-conversion function	Frequency setting of each up-conversion function
Frequency setting of each down-conversion function	Frequency setting of each down-conversion function
Auto-track source (frequency band)	Auto-track status
Total and individual carrier power level at antenna feed	Total and individual communications carrier power level at antenna feed
Antenna pointing angles (azimuth and elevation relative to true north)	Antenna pointing angles (azimuth and elevation relative to true north)
Signal path switches (redundant equipment and waveguide switches)	Equipment fault status
--	Total transmit power level at the power amplifier output
--	Transmit gain/loss setting from the output of each up-conversion function to the input of the HPA
--	Transmit gain setting of the power amplifier
--	Receive gain setting from LNA input to each down-conversion function output
--	Receive gain setting of each down-conversion function

CHAPTER 6. NOTES

(This section contains information of a general or explanatory nature that may be helpful but is not mandatory.)

6.1 Intended use. This standard is intended to define the military SHF SATCOM ET interfaces in terms of physical and functional performance criteria necessary to support PMs and buying activities in the acquisition of interoperable and compatible ETs, which are vital for effective joint and combined forces communication. This document is heavily drawn from the U.S. MIL-STD-188-164C but should be considered a standalone document.

6.2 Acquisition requirements. Acquisition documents should specify the title, number, and date of this standard. Acquisition programs should also consider any additional requirements mandated by the desired SCPA(s) for access to a given satellite constellation in addition to any program specific requirements.

6.3 Tailoring guidance. To ensure proper application of this standard, invitations for bids, requests for proposals, and contractual statements of work (SOWs) can specify which of the requirements in chapter 5 of this standard apply and should state exclusion to any non-applicable requirements (for example, environmental requirements). Specific values are modified in the appendices to this document to address specific ET types. It is highly recommended that any exclusions be coordinated with the appropriate SCPAs to avoid any issues during ET performance evaluation.

6.4 Subject term (keyword) listing. The following keywords apply to this AComP.

COMSATBw
K_a-band, military
SATCOM
SICRAL
SKYNET
SPAINSAT-NG
SYRACUSE
Wideband Global SATCOM (WGS)
X-band

6.5 RSS Theory. RSS is a method of determining the more likely overall variation of a sum $X = \sum x_k$ of components which each may vary. If each component x_k has a mean value m_k, then the mean $M = \sum m_k$ of the sum X and total deviation

$$X - M = \sum (x_k - m_k) = \sum \Delta x_k$$

Where:

$\Delta x_k = x_k - m_k$ denotes the deviation of the x_k component from its mean value.

If the component deviations take the values $\pm\Delta x_k$ with equal probability and they are mutually uncorrelated, the sum of squares $\sum(\Delta x_k)^2$ is the variance and the RSS $\sqrt{\sum(\Delta x_k)^2}$ is the standard deviation of the sum $X = \sum x_k$. Generally, since the various deviations seldom all add, or subtract, the RSS value represents a more likely and appropriate measure for the total variation of the sum, even if the RSS value cannot be justified on strict probabilistic arguments.

6.6 Antenna gain versus pointing variations. Since the degrees off beam of the uplink beam will degrade the EIRP in the direction of the satellite, this change is of concern for EIRP stability. The formula to approximate the reduction in gain of a circularly symmetric parabolic antenna due to pointing error is as follows:

$$A(dB) = 12\left(\frac{\beta}{\varphi}\right)^2$$

Where:

A = attenuation (dB);
β = uplink pointing error (degrees);
φ = 3-dB beam width (degrees).

6.6.1 Example. If the uplink beam is offset 0.01° from alignment, then, for a 38-ft (11.5824-m) antenna at 8.4 GHz with φ at 0.219089023°, the attenuation is 0.025 dB. If, because of pointing errors, the uplink beam is now offset by 0.03°, the attenuation is 0.225 dB. Thus, if the control system changes the pointing error from 0.01° to 0.03°, the EIRP will change by 0.2 dB. This change must be accounted for in the RSS equation.

6.6.2 Satellite motion. It is important to note that satellite motion also can impact this loss. ET design must account for EIRP errors due to satellite motion regardless of whether the ET has a pointing control system.

6.7 Accounting for pointing loss differences between uplink and downlink beams. Because beam width is a function of the frequency used, and because pointing loss is determined by measuring variations in the downlink satellite beacon, the actual uplink loss will differ from the downlink loss. At X-band frequencies, the frequency separation is relatively small, and the difference between uplink and downlink pointing losses is negligible. However, at K_a-band frequencies, the 10-GHz separation between the uplink and downlink can cause significant differences. For the purposes of EIRP stability, uplink pointing loss will be greater than downlink pointing loss and will therefore be used in the RSS equation in 4.2.4. Unless otherwise specified, the equation for calculating the uplink pointing loss based on the measured downlink loss is as follows:

$$L_{\mathrm{up}} = L_{\mathrm{down}} \left(\frac{F_{\mathrm{up}}}{F_{\mathrm{down}}} \right)^2$$

Where:

L_{up} = pointing loss on the uplink at the given frequency (dB);
L_{down} = pointing loss on the downlink at the given frequency (dB);
F_{up} = highest operational uplink frequency;
F_{down} = frequency of the downlink beacon.

Simultaneous multiband terminals are recommended to use the highest frequency beacon signal for tracking purposes.

6.7.1 Exceptions. Should the uplink and downlink beams be significantly misaligned, or should they originate from different apertures, the equation in 6.7 does not apply. In such cases, the individual beams will need to be compared to determine the uplink loss corresponding to a downlink loss due to mispointing. This will be accomplished by converting the downlink pointing loss from 4.3.12 into a pointing error based on the downlink beam pattern. Assuming the uplink and downlink beam pointing is coupled, this receive pointing error is then applied to the uplink beam to determine the transmit pointing loss to be used in 4.2.4. For ETs with asymmetric beam shapes, these calculations will be done at the lowest-performance operational orientation of the beams.

6.7.2 Example. On the WGS system, the downlink K_a-band beacon is at 20.7 GHz, while the uplink frequencies range between 30 and 31 GHz. Using these numbers, along with a hypothetical circular, center-fed ET having a measured downlink loss of 1.0 dB, gives an uplink loss of between 2.1 and 2.24 dB. In this case, the lowest-performance uplink frequency loss of 2.24 dB would be utilized as the P_2 loss component for calculating total EIRP stability (see 4.2.4).

6.8 STANAG 5648 compliance statements. This AComP ensures interoperability on the satellite constellations listed in TABLE I. Due to the vast array of ETs and the individual requirements of the given constellations, it becomes necessary to clearly identify on which constellations an ET is authorized to operate. This is referred to as a STANAG compliance statement. The format for a STANAG compliance statement is shown in 1.5.

6.8.1 STANAG testing and additional SCPA requirements. This AComP sets forth one phase of commissioning testing for constellations referenced in TABLE I. A second phase of testing may, or may not, be deemed necessary by the relevant SCPA (see 1.4). FIGURE 3 illustrates the relationship between AComP testing and SCPA testing.

a. AComP testing is effectively divided between the common requirements in sections 4.1 and 5.1 and the individual requirements listed in TABLE I. It is recommended that test planners begin with the common requirements in sections 4.1 and 5.1. Failure of any requirement in these sections disqualifies the terminal from all constellations.

b. After testing the common requirements, a constellation is chosen from TABLE I. The ET in question is tested against those individual requirements. Failure to meet those individual requirements do not necessarily disqualify the ET from attaining a compliance statement. It only disqualifies the ET from a statement for that specific constellation. An ET may not meet one constellation's requirements, but it may meet the requirements of another. When support for multiple constellations is desired, an ET may require the operator to toggle a mode to switch between constellations. Simultaneous support for multiple constellations without reconfiguration is permitted but is not required by this AComP.

c. After successful AComP testing, the relevant SCPA is contacted for commissioning. Test results will be presented in accordance with the SCPA submission guidelines. The SCPA will decide if additional testing is required.

d. Once any additional testing is completed and the ET has successfully been commissioned, the ET may claim a compliance statement for that constellation only.

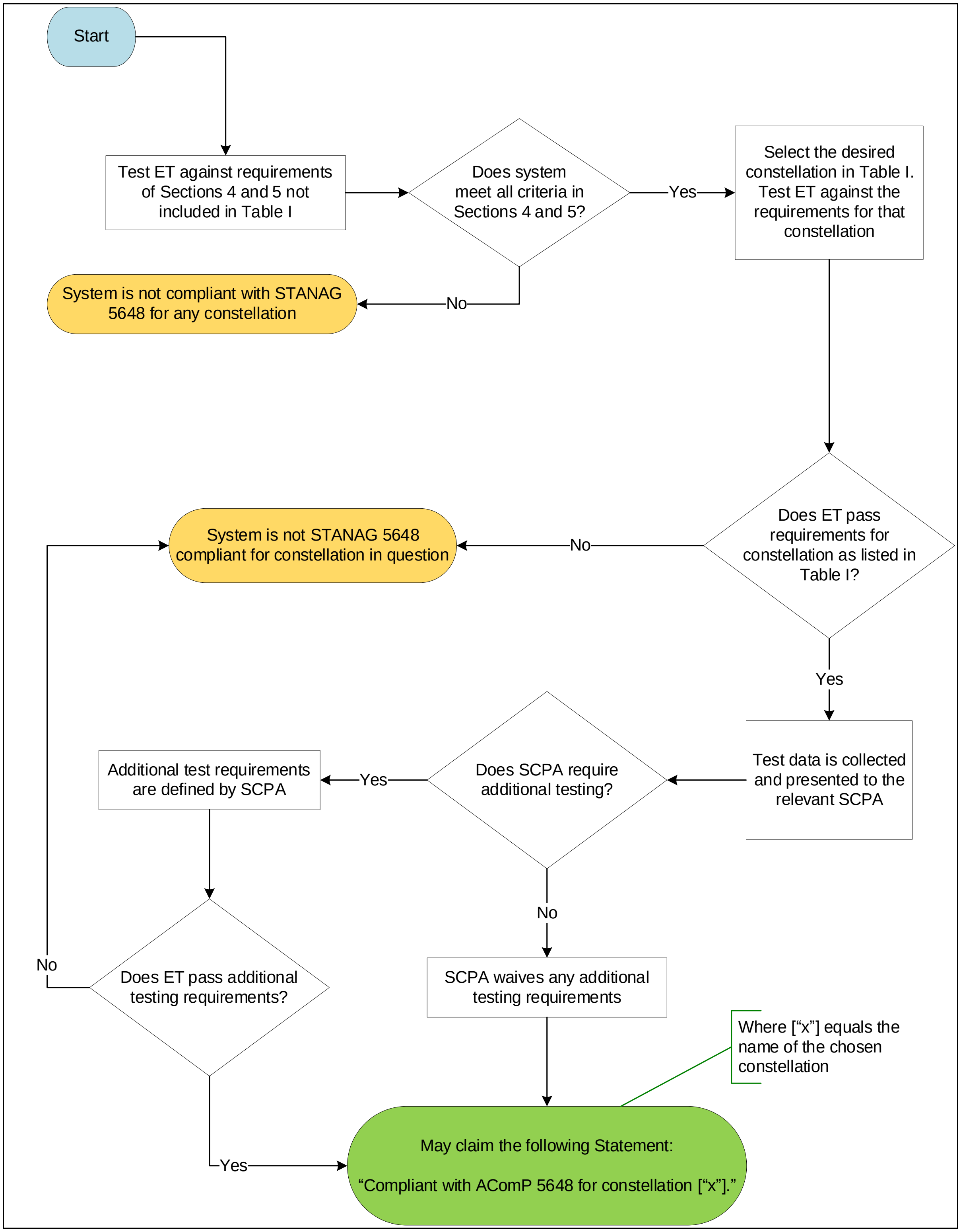

Start
Test ET against requirements of Sections 4 and 5 not included in Table I
Does system meet all criteria in Sections 4 and 5?
Yes
Select the desired constellation in Table I. Test ET against the requirements for that constellation
No
System is not compliant with STANAG 5648 for any constellation
Does ET pass requirements for constellation as listed in Table I?
No
System is not STANAG 5648 compliant for constellation in question
Yes
Test data is collected and presented to the relevant SCPA
Does SCPA require additional testing?
Yes
Additional test requirements are defined by SCPA
No
SCPA waives any additional testing requirements
Does ET pass additional testing requirements?
No
Yes
Where ["x"] equals the name of the chosen constellation
May claim the following Statement:
"Compliant with AComP 5648 for constellation ["x"]."

FIGURE 3. STANAG compliance statement decision tree

6.8.2 Multiple STANAG compliance statements. Once an ET has secured an initial compliance statement, the program office responsible for the ET may wish to operate on multiple constellations. An ET is not limited in the number of STANAG compliance statements it may attain provided it meets the requirements listed TABLE I.

6.8.2.1 Identical Table I requirements. If an ET receives a compliance statement for a constellation, it is for that constellation only. There is no guarantee of reciprocity between different SCPAs. If the TABLE I values for two constellations are identical, the compliance statement does not automatically grant access to the second constellation. The second constellation's SCPA must be contacted separately and presented with the test data that led to the ETs first compliance statement.

The second constellation's SCPA will make the determination to accept the data or require additional testing. Once the SCPA is satisfied, an amended compliance statement can be claimed for the second constellation being:

"Compliant with AComP 5648 for Constellations [x] and [y]"

Where [x] and [y] are the names of the relevant constellations. The ET would then be authorized to operate on those constellations only.

6.8.2.2 Overlapping Table I requirements. Many individual requirements in TABLE I apply to more than one constellation. In practice, it is likely a second constellation will have some, but not all, requirements in common.

a. Since the majority of requirements in sections 4.1 and 5.1 were passed in securing the ETs initial compliance statement, an SCPA may consider those results sufficient. If so, testing could begin with the individual TABLE I requirements.

b. It is recommended that test planners take into consideration what values in TABLE I overlap between constellations. For example, an ET seeking a second compliance statement could have six of the fourteen TABLE I values overlapping. An SCPA may consider those results sufficient. If so, it would not be necessary to test the overlapping six requirements.

c. Further, the same ET with six of the fourteen overlapping requirements may have a seventh requirement in TABLE I which is more stringent than the constellation it seeks to be commissioned on. An SCPA, at their discretion, could consider such a result sufficient, if so, it would not be necessary to test the more stringent seventh requirement.

Only the remaining tests, in this example there would be seven, would need to be passed successfully.

d. Final test results would be presented in accordance with the SCPA submission guidelines. Regardless of the test data presented the SCPA may still decide additional testing is required.

Once the SCPA is satisfied, an amended compliance statement can be claimed for the second constellation being:

"Compliant with AComP 5648 for Constellations [x] and [y]"

Where [x] and [y] are the names of the relevant constellations. The ET in question would then be authorized to operate on those constellations only.

6.8.2.3 Three or more Compliance Statements. This process could be repeated to add more constellations. The format of such a statement would be:

"Compliant with AComP 5648 for Constellations [x], [y], and [z]"

Where [x], [y], and [z] are the names of the relevant constellations. Additional constellations names would be added in this manner up to the total number required. The ET in question would then be authorized to operate on those constellations only.

APPENDIX A

LAND-BASED SATCOM OTM EARTH TERMINALS

A.1 Scope. This appendix applies to land-based SATCOM systems that operate while OTM. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance and may replace specific requirements in the body of the standard (see 1.6b).

A.2 Uplink inhibit. OTM ETs shall immediately inhibit transmit upon loss of the downlink signal.

A.3 Antenna pointing loss. The following replaces the entire text of 4.3.12, Antenna Pointing Loss.

A.3.1 For SICRAL: Requirements per WGS, see paragraph A.3.4.

A.3.2 For Skynet: Requirements per WGS, see paragraph A.3.4.

A.3.3 For Syracuse: Not applicable.

A.3.4 For WGS:

"**4.3.12 Antenna pointing loss**. The downlink loss due to antenna pointing error shall not exceed 0.8 dB 95.4 percent of the time. The loss shall be translated to the appropriate uplink loss in accordance with 6.8 and shall be used as the P2 RSS contribution to the EIRP stability and accuracy specification in 4.2.4; P2 is defined as the power variation in the direction of the satellite caused by pointing loss. The antenna pointing loss requirement is applicable to a blockage-free environment and does not include any time frame during which the antenna system supports a non-operating mode by design (for example, when not operating due to safety considerations)."

A.3.5 For COMSATBw: Not applicable.

A.3.6 For SPAINSAT-NG: Not applicable.

APPENDIX B

AIR-BASED SATCOM OTM EARTH TERMINALS

B.1 Scope. This appendix applies to air-based SATCOM systems that operate while OTM. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance and may replace specific requirements in the body of the standard (see 1.6b).

B.2 EIRP stability and accuracy. The following replaces 4.2.4, EIRP Stability, when an ET's modulated signal occupies the entire bandwidth of the transponder.

"**4.2.4 EIRP stability.** For any setting of the transmission gain and a constant IF input level, the EIRP in the direction of the satellite shall not vary more than 3.5 dB peak to peak in any 24-h period. This tolerance, added on an RSS basis, includes all ET factors contributing to the EIRP variation, including output power level instability (including radome insertion loss variations with look angle) and power variations due to pointing losses. See 6.5–6.7 for RSS theory and determination of power variations due to pointing losses. The formula for RSS error is

$$\sqrt{P_1^2 + P_2^2}$$

Where:

P_1 = transmission function output power level instability in dB.
P_2 = uplink power variations, in dB, in the direction of the satellite caused by pointing losses as described in 4.3.12 and 6.7.

For dual-band simultaneous operation, the variable P_2 shall be evaluated in the highest operational RF band."

B.3 Carrier frequency accuracy and stability. The following replaces 4.2.5, Carrier Frequency Accuracy and Stability.

"**4.2.5 Carrier frequency accuracy and stability.** The carrier frequency at the antenna feed shall be within 1 kHz of the intended value. The carrier frequency accuracy shall be maintained for the maximum mission duration without calibration."

B.4 Receive conversion frequency accuracy. The following replaces 4.3.5, Receive Conversion Frequency Accuracy.

"**4.3.5 Receive conversion frequency accuracy.** The down-conversion frequency accuracy shall be within 1 kHz of the intended value for all received carriers. Down-conversion frequency accuracy shall be maintained for the maximum mission duration without calibration."

B.5 Antenna pointing loss. The following replaces the entire text of 4.3.12, Antenna Pointing Loss.

B.5.1 For SICRAL: Requirements per WGS, see paragraph B.5.4.

B.5.2 For Skynet: Requirements per WGS, see paragraph B.5.4.

B.5.3 For Syracuse: Not applicable.

B.5.4 For WGS:

"**4.3.12 Antenna pointing loss**. The downlink loss due to antenna pointing error shall not exceed 0.8 dB 95.4 percent of the time. The loss shall be translated to the appropriate uplink loss in accordance with 6.8 and used as the P2 RSS contribution to the EIRP stability and accuracy specification in 4.2.4; P2 is defined as the power variation in the direction of the satellite caused by pointing loss. This requirement shall be met under operational flight conditions with no airframe blockage or keyhole events. A mechanism shall be provided to inhibit transmit in the event that the antenna transmit pointing error causes the off-axis ESD limit to be exceeded."

B.5.5 For COMSATBw: Not applicable.

B.5.6 For SPAINSAT-NG: Not applicable.

APPENDIX C

ARRAY-BASED SATCOM OTM EARTH TERMINALS

C.1 Scope. This appendix applies to array-based SATCOM systems that operate while OTM. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance and may replace specific requirements in the body of the standard (see 1.6b).

C.2 EIRP stability. The following replaces 4.2.4, EIRP Stability.

"**4.2.4 EIRP stability.** For any fixed scan angle, any setting of the electronic transmit gain, and a constant IF input level, the EIRP in the direction of the satellite shall not vary more than 2.5 dB peak to peak in any 24-h period."

C.3 Transmit-to-receive isolation. The following replaces 4.2.15, Transmit-to-receive isolation.

"**4.2.15 Transmit-to-receive isolation.** Transmit-to-receive isolation shall be such that there is less than a 0.5-dB increase, and no decrease, in receive noise density over the applicable frequency range shown in TABLE III with the transmitter operating at any EIRP level, compared to the receive performance with the transmitter turned off."

C.4 Receive signal level stability. The following replaces 4.3.11, Receive Signal Level Stability.

"**4.3.11 Receive signal level stability.** For a fixed scan angle, any setting of the receive gain, and a constant PSD level, the reception function output level shall not vary more than 2.0 dB in any 24-h period."

APPENDIX D

CONSTELLATION SPECIFIC ESD PERFORMANCE LIMITS

D.1 Scope. This appendix provides constellation specific ESD performance limits. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance and may replace specific requirements in the body of the standard (see 1.6b).

D.2 SICRAL ESD Limits.

D.2.1 K_a-Band. Requirements per WGS, see paragraph D.5.1.

D.2.2 X-Band. Requirements per WGS, see paragraph D.5.2.

D.3 Skynet ESD Limits.

D.3.1 K_a-Band. Requirements per WGS, see paragraph D.5.1.

D.3.2 X-Band. Requirements per WGS, see paragraph D.5.2.

D.4 Syracuse ESD Limits.

D.4.1 K_a-Band. For all ETs, ESD in the GSO plane shall not exceed the following:

a. The limits defined by ITU-R S.524-9 for the 27.5-30.0 GHz frequency band. This is also extended to the 30.0-31.0 GHz frequency band.

b. For very small terminals Syracuse may authorize the ESD limits defined by ITU Radio Regulations Article 22.32.

D.4.2 X-Band. For all ETs, ESD in the GSO plane shall not exceed the following:

a. $ESD(\theta) = 0 - 25 \log_{10}(\theta)$ (dBW/Hz) for $2° \leq \theta \leq 180°$

Where: θ = the off-axis angle in the direction of the GSO plane refers to the main-lobe axis.

D.5 WGS ESD Limits.

D.5.1 K_a-Band. For all ETs, ESD in the GSO plane shall not exceed the following:

a. $ESD(\theta) = -6.4 - 25 \log_{10} \theta$ (dBW/Hz) for $2.0° \le \theta < 20.0°$

b. $ESD(\theta) = -38.9$ (dBW/Hz) for $20.0° \le \theta \le 26.3°$

c. $ESD(\theta) = -3.4 - 25 \log_{10} \theta$ (dBW/Hz) for $26.3° < \theta < 48.0°$

d. $ESD(\theta) = -45.4$ (dBW/Hz) for $48° \le \theta \le 180°$

Where: θ = the off-axis angle in the direction of the GSO plane refers to the main-lobe axis

The ESD requirement shall be met while incorporating transmit RMS pointing errors. FIGURE D-1 illustrates the ESD mask defined by the above parameters.

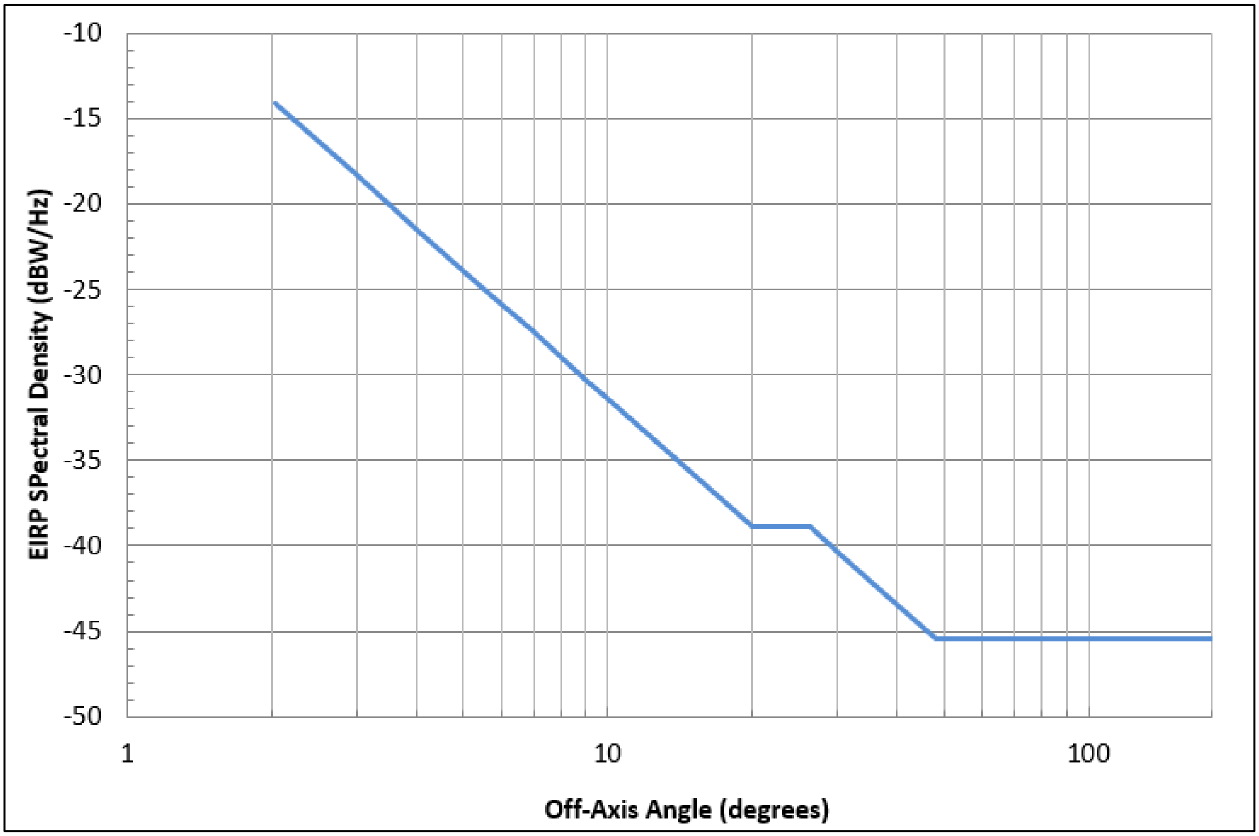


FIGURE D-1. WGS K_a-band EIRP spectral density mask

D.5.2 X-Band. For all ETs, ESD in the GSO plane shall not exceed the following:

a. $ESD(\theta) = 2.351 - 25 \log_{10} \theta$ (dBW/Hz) for $2.0° \leq \theta < 3.8°$

b. $ESD(\theta) = -13.0$ (dBW/Hz) for $\theta = 3.8°$

c. $ESD(\theta) = 1.49 - 25 \log_{10} \theta$ (dBW/Hz) for $3.8° < \theta < 5.0°$

d. $ESD(\theta) = -3.97 - 25 \log_{10} \theta$ (dBW/Hz) for $5.0° \leq \theta < 6.94°$

e. $ESD(\theta) = -25.0$ (dBW/Hz) for $6.94° \leq \theta \leq 12.42°$

f. $ESD(\theta) = 2.35 - 25 \log_{10} \theta$ (dBW/Hz) for $12.42° < \theta < 48.0°$

g. $ESD(\theta) = -39.65$ (dBW/Hz) for $48° \leq \theta \leq 180°$

Where: θ = the off-axis angle in the direction of the GSO plane refers to the main-lobe axis.

The ESD requirement shall be met while incorporating transmit RMS pointing errors. FIGURE D-2 illustrates the mask defined by the above parameters.

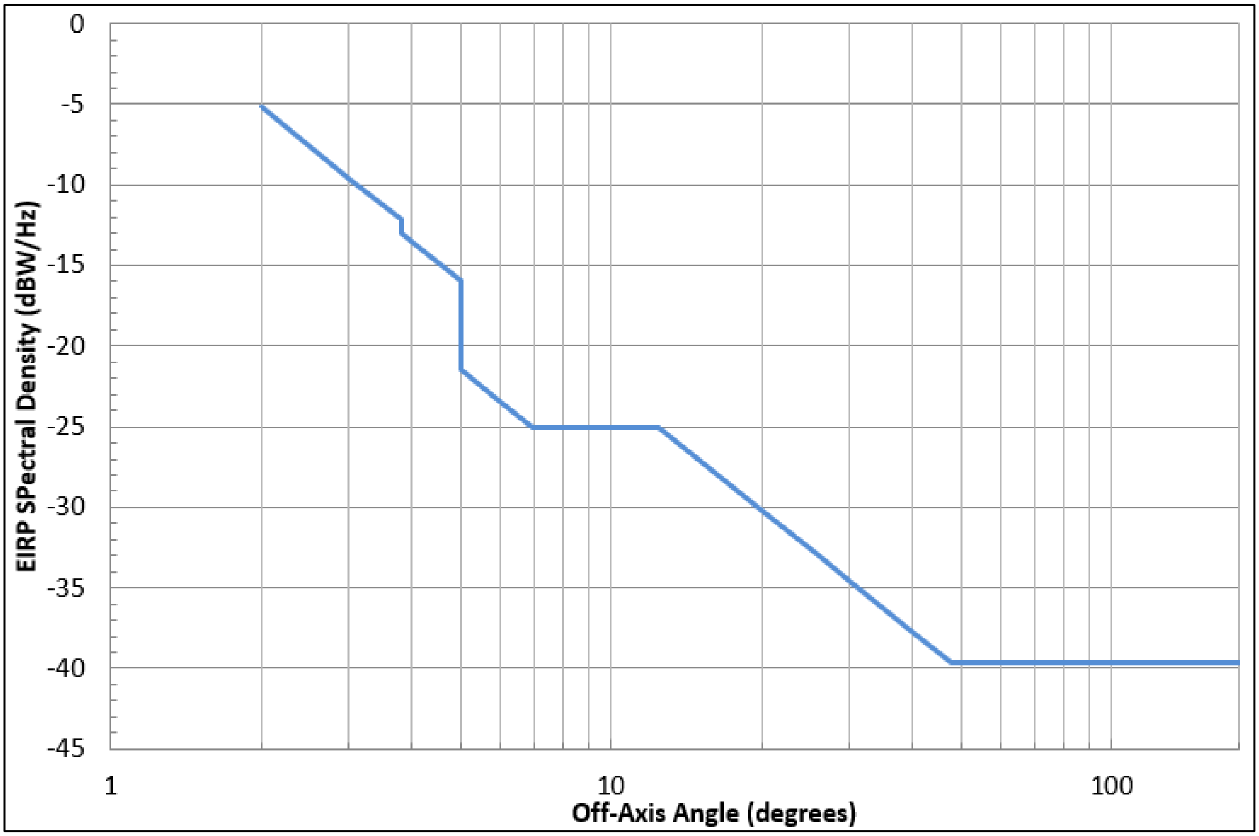


FIGURE D-2. WGS X-band EIRP spectral density mask

D.6 COMSATBw ESD Limits.

D.6.1 K_a-Band. Not applicable.

D.6.2 X-Band. For all ETs, ESD in the GSO plane shall not exceed the following:

a. ESD(θ) = −3.0 (dBW/Hz) − 25 $\log_{10}$ θ (dBW/Hz) for 6.0° ≤ θ < 48.0°

b. ESD(θ) = −45.0 (dBW/Hz) for θ = 48.0° ≤ θ < 180.0°

Where: θ = the off-axis angle in the direction of the GSO plane refers to the main-lobe axis.

D.7 SPAINSAT-NG ESD Limits.

D.7.1 K_a-Band. Requirements per WGS, see paragraph D.5.1.

D.7.2 X-Band. Requirements per WGS, see paragraph D.5.2.

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