FCC Form 312
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SAT-AMD-_____-_____
Call Sign: S2110

Engineering Statement Supplement

Harris VHF Payload Hosted on Iridium NEXT

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Iridium herein supplements the Engineering Statement provided with its Iridium NEXT application (the "Original Engineering Statement").[1] This Engineering Statement Supplement (the "Engineering Supplement") accompanies an amendment in which Iridium is seeking authority to operate a VHF receive-only payload that will be hosted on the Iridium NEXT constellation (the "VHF Payload").[2]

In its Original Engineering Statement, Iridium provided technical information required under Section 25.114 of the Commission's rules and other FCC rules that address the frequency bands that are to be used by Iridium NEXT. The information was organized into 18 subject matter sections labeled "A" through "S." In this Engineering Supplement, Iridium supplements the information in these subject matter sections, as applicable, to take the VHF Payload into account. Iridium also has added a 19th subject matter section, labeled "T," to address the Commission's default service rules. Except as stated in this Engineering Supplement, Iridium is making no changes to the technical information it provided in its Original Engineering Statement.[3]

In addition to the technical rule waivers requested in the Original Engineering Statement, Iridium seeks waivers in this Engineering Statement of Sections 25.114(c)(4)(vi)(B), 25.210(f), 25.210(i), and 25.287 of the Commission's rules, to the extent required.

A. APPLICANT

No change, except that Iridium previously notified the Commission of a change in the person to whom inquiries and correspondence should be directed.[4]

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[1] *See* IBFS File No. SAT-MOD-20131227-00148.

[2] The VHF Hosted Payload will be included on 65 Iridium NEXT satellites: 56 of the initial satellites in mission orbit, 4 in-orbit spares, and 5 ground spares. The exact number of mission orbit satellites operating with the VHF Hosted Payload may increase or decrease should initial mission satellites fail, in-orbit spares be activated, or ground spares be launched and activated. The first two Iridium NEXT satellites scheduled for launch in December 2015 will not contain the VHF Hosted Payload.

[3] Since the filing of the Iridium NEXT application in 2013, the Commission has revised the Part 25 rules governing the information required for space station applications. Comprehensive Review of Licensing and Operating Rules for Satellite Services, IB Docket No. 12-267, *Report and Order*, 25 FCC Rcd 12403 (2013); *see also* International Bureau Adopts Policy of Granting Interim Waiver of Certain Requirements for Space Station Applications, Report No. SPB-255, *Public Notice*, 29 FCC Rcd 664 (2014). Accordingly, this amendment includes only new and supplemental information required under current Commission rules and policy.

[4] *See* Letter from Jennifer D. Hindin, Counsel to Iridium Constellation LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, IBFS Docket No. SAT-MOD-20131227-00148 (dated May 7, 2015).

B. AUTHORIZATION REQUESTED

In this amendment, Iridium seeks authority for 56 of the Iridium NEXT replacement satellites and four of the in orbit spares to host a receive-only VHF Payload. Five ground spares will also include the VHF Hosted Payload.

C. IRIDIUM NEXT DESCRIPTION (47 C.F.R. § 25.114(d))

The receive-only maritime VHF Hosted Payloads will be comprised of fifty-six (56) low-Earth orbit payloads riding and operating as hosted payloads onboard the Iridium NEXT satellite constellation. Schedule S describes in greater detail the required technical information with regard to the design of the receivers for which authority is requested in this amendment.

Health, status, monitoring, and associated control signals for the VHF hosted payload receivers will be managed and controlled via the Hosted Payload Operations Center ("HPOC"), located at the Iridium Satellite Network Operations Center in Leesburg, Virginia ("SNOC"). All command and control data transmitted to and mission data and telemetry received from the VHF receiver hosted payloads will travel as standard Iridium data packets over the Iridium NEXT inter-satellite crosslinks and/or feeder links and TPN earth station networks. VHF data transmitted from the ships (and received terrestrially in the areas near land) will be received by the VHF Hosted Payload receivers even while deep at sea and not within range of any other ship-based receivers, significantly expanding the coverage area of the maritime VHF services. There is no change in the operational technical transmission parameters of the maritime terminals required in order for these signals to be received by the VHF Hosted Payload.

The maritime user transmission characteristics are identical for both the satellite and terrestrial reception of the VHF signals. When the VHF mission data is received at the satellite, it is retransmitted over the Iridium network to the Iridium feeder link earth station. When the mission data is received on the ground at the HPOC, VHF receiver data is sent via a Virtual Private Network (VPN) connection to the Harris facility located in Melbourne, FL for subsequent processing and eventual delivery to customers.

The Harris VHF receiver system is a satellite constellation-based hosted payload providing maritime domain awareness through the collection of VHF signals and emissions for Automatic Identification System ("AIS"), Application Specific Messages ("ASM"), Digital Selective Calling ("DSC") and maritime distress, urgency and safety calling, for various users and consumers. The VHF Hosted Payload will be used to provide maritime VHF services on a global basis. Non-satellite maritime communications will remain subject to local regulatory authorization in each administration that the AIS and other signals are provided or from each administration's registered maritime vessel. The VHF Hosted Payload receiver is capable of operating throughout the frequency range 156.0125-162.0375 MHz. Iridium is requesting launch authority for the receiver for the entire 156.0125-162.0375 MHz band but operating authority

only for the specific frequencies providing AIS, ASM, DSC and maritime distress, urgency and safety calling that are identified in this Engineering Supplement and Schedule S.

The VHF Hosted Payload on each satellite is comprised of a receiver with two receive antennas: an omnidirectional antenna and a collinear antenna. Both antennas operate simultaneously in the 156.0125-162.0375 MHz frequency band. Section J (**SERVICES and TRANSMISSON CHARACTERISTICS**) of this Engineering Supplement and Figures 105 through 110 in Appendix A describe the two VHF satellite receive antennas and provide associated technical details.

D. ORBITAL INFORMATION

No change.

E. CONSTRUCTION AND LAUNCH SCHEDULE

Although the first launch of the Iridium NEXT satellite constellation is currently planned for December 2015, space vehicles including the VHF Hosted Payload are not expected to begin launching until the second Iridium NEXT launch, scheduled for four months after the initial launch and currently expected to take place in April 2016. VHF Hosted Payload-equipped satellites will be included on each subsequent Iridium NEXT launch.

F. SATELLITE NETWORK CONTROL

No change.

G. FREQUENCY and POLARIZATION (47 C.F.R. § 25.114(c)(4)(i))

The channel center frequencies and bandwidths are provided in Schedule S. The channels are 25 kHz wide, and the VHF hosted payload receiver is capable of operating throughout the 156.025 to 162.025 MHz channels spaced at 25 kHz. The specific center frequencies requested for operational authority at this time are:

156.525 MHz (DSC-R),

156.775 MHz (Long Range AIS 1 or AIS 3),

156.8 MHz (maritime mobile distress),

156.825 MHz (Long Range AIS 2 or AIS 4),

161.950 MHz (ASM 1),

161.975 MHz (AIS 1),

162.00 MHz (ASM 2), and

162.025 MHz (AIS 2).

Horizontal polarization is received on all above channels and throughout the 156.0125-162.0375 MHz band.

H. BAND FREQUENCY REUSE

See Section T, below ("Default Services Rules") concerning compliance of the VHF Payload with Sections 25.210(f) and 25.210(i) of the rules.

I. EMISSION INFORMATION

The additional emission information associated with the VHF Hosted Payload receiver is provided in Schedule S.

J. SERVICES and TRANSMISSON CHARACTERISTICS (47 C.F.R. §§ 25.114(c)(4)(v)—(vi))

The gain to temperature ratio for the two VHF receive antenna beams is specified in Schedule S.

Iridium will be deploying its new VHF receivers on the Iridium NEXT low-Earth orbit non-geostationary satellite system, and thus is not requesting a nominal orbit location. Rather, as previously described (and in greater detail in the Schedule S), Iridium will be deploying these VHF receivers onto the Iridium NEXT constellation of constantly moving satellites relative to the surface of the Earth. Appendix A Figure 105 includes a depiction of the two representative VHF receiver antenna gain contours for a single satellite. These representative patterns are the same for each of the VHF receiver payloads on each of the 56 satellites in the Iridium NEXT constellation. The other 10 satellites in the Iridium NEXT constellation will not include the VHF hosted payload and therefore do not have these two VHF antennas.

Iridium is requesting a waiver of Section 25.114(c)(4)(vi)(B) regarding the depiction of antenna gain contours. The representative antenna gain contour (Figure 105 in Appendix A), provided for the omnidirectional antenna and the collinear antenna, is a – 3db antenna gain contour at satellite nadir for one point in the service area in the United States. It does not include the specific 2 dB, 4 dB, 6 dB, 8 dB, 10 dB, 15 dB, and 20 dB contours required by this rule but Figures 107 and 109 provide color pictorials of normalized antenna gain over ground for the collinear antenna and omnidirectional antenna, respectively, which shows areas of gain ranges from 0-12 dB. Consequently, a waiver is requested for submitting the gain contour information in this format for both antennas.

The omnidirectional and collinear antenna "footprints" remain fixed with respect to each other and are not steerable individually or collectively. Each VHF receiver hosted payload is designed to have a uniform coverage pattern, but the resulting "fixed footprint" constantly moves relative to the surface of the Earth as the host satellite orbits.

Appendix A Figure 106 also includes a depiction of the satellite constellation "footprint" at one point in time to demonstrate typical service coverage for the 56 Hosted Payload satellite constellation as a whole.

Appendix B to this Narrative Description includes link budgets for these VHF signals specifically for AIS, ASM, DSC signals and maritime distress channel for the two VHF receive antenna patterns.

There are several items that should be kept in mind with respect to the Schedule S data and the link budgets that were used as a reference to complete that form. With regard to the link budgets, the values that are used are estimated calculations based on expected values. The actual operational values will depend on the final VHF receiver implementation details. Values such as the link margin are defined with respect to Eb/No, not C/No. This is due to the fact that the VHF Hosted Payload receiver system uses digital communications collection and processing. The signals received by the VHF Hosted Payload receivers are digitized, demodulated and their content evaluated on board the satellite. Thus, the link budgets are derived from the development of requirements for digital communication receiver design. The Cross Polarization Isolation (XPI) is not a parameter to which the VHF Hosted Payload receiver system will be sensitive. The VHF Hosted Payload system uses time differences, frequency separation/doppler and signal level, not polarization, in order to discriminate between multiple VHF (*e.g.*, AIS) signals on the same frequency arriving at the satellite receivers. The VHF Hosted Payload receiver also uses the two antennas simultaneously to discriminate between several AIS transmissions. The subscriber terminals are linearly polarized and cross polarization is not used to discriminate between multiple simultaneous transmitted signals on the same frequency. As a result, the requested information on cross-polarization in Schedule S is irrelevant. Nevertheless, to the extent that this information is required to be provided in Schedule S, Iridium requests a waiver since the cross polarization information for the two VHF receive antenna patterns is not available.

K. PFD REQUIREMENTS

No change.

L. PUBLIC INTEREST and COMMON CARRIER CONSIDERATIONS

As discussed in the Legal Narrative and Public Interest Statement accompanying this amendment, authorizing Iridium to launch and operate the VHF Hosted Payload is in the public interest.

M. SPACE STATION PHYSICAL CHARACTERISTICS

No change. There is no longer an FCC requirement to provide this information.

N. ORBITAL DEBRIS MITIGATION and REENTRY INFORMATION

No change.

O. LICENSING REQUIREMENTS

No change.

P. IN-ORBIT SPARES

No change in the number of in-orbit and ground spares is requested through this amendment, but the VHF Hosted Payload will be installed on four (4) of the in-orbit spares and five (5) of the ground spares.

Q. ITU INFORMATION (47 C.F.R. § 25.111)

Iridium will not be submitting at this time Advance Publication Information and a coordination request for mobile satellite service operation on the AIS 1 and AIS 2 bands. These AIS channels are recognized internationally and are expected to be protected. If it is subsequently determined that there is need to submit the Advance Publication information and coordination request to secure the appropriate interference protection, this information will be submitted separately at that time.

R. COORDINATION

No change.

S. INTERSATELLITE SERVICE LINKS

No change.

T. DEFAULT SERVICE RULES (47 C.F.R. § 25.217)

Although there is an Earth-to-Space allocation for mobile satellite service use of the 161.9625-161.9875 (AIS 1) and 162.0125-162.0375 MHz (AIS 2) bands in the United States, the Commission has not adopted service rules for mobile satellite service operations in these bands. Therefore, the Commission's default service rules apply to the use of these frequencies in the United States and vessels under U.S. jurisdiction.

For NGSO satellite systems, Section 25.217(b) of the default rules applies. Section 25.217(b)(1) specifies that the satellite system will need to comply with the technical requirements of § 25.142(d), § 25.143(b)(2)(ii), § 25.143(b)(2)(iii), § 25.204(e), § 25.210(d), § 25.210(f), and § 25.210(i). Section 25.217(b)(2) states the requirements in § 25.142(b)(2)(ii) are to be used for Commission coordination with Federal Government users in shared government/non-government frequency bands. Section 25.217(b)(3) states that NGSO mobile earth stations must comply with the requirements in § 25.285 and § 25.287; and with the requirements in § 25.203(c) in frequency bands shared with terrestrial wireless services.

Sections 25.217(b)(1) and (3) state that NGSO satellite systems must comply with the rule provisions listed "notwithstanding the frequency bands specified in these rule provisions." In some cases, the rule provisions specify not frequency bands but satellite services (*e.g.*, the Broadcasting Satellite Service), and it is unclear whether the "notwithstanding" clause applies to satellite services, too. Out of an abundance of caution, Iridium's compliance showing takes into account the possibility that these rule provisions apply to Iridium even when the rule provisions, by their terms, are limited to satellite services other than Iridium's satellite services.

Compliance with these requirements is addressed below.

1. § 25.142(d) Prohibition of certain agreements.

The statement demonstrating compliance with this rule section in the Iridium NEXT application also applies to the AIS 1 and AIS 2 channels at 161.975 and 162.025 MHz. It also applies to the ASM, DSC and maritime distress channels that will operate on an unallocated non-protected basis.

2. § 25.143(b)(2)(ii).

The Iridium NEXT application includes a statement which demonstrates compliance with Section 25.143(b)(2)(ii). This statement also applies to the 161.975 MHz and 162.025 MHz channels. It also applies to the ASM, DSC, and maritime distress channels that will operate on an unallocated, non-protected basis.

3. § 25.143(b)(2)(iii).

The Iridium NEXT application includes a statement which demonstrates compliance with Section 25.143(b)(2)(ii). This statement also applies to the 161.975 MHz and 162.025 MHz channels. It also applies to the ASM, DSC, and maritime distress channels that will operate on an unallocated, non-protected basis.

4. § 25.210(f).

Section 25.210(f) is intended for space stations in the Fixed-Satellite Service and requires that space stations operating in specified bands employ frequency reuse "either through the use of orthogonal polarizations within the same beam and/or the use of spatially independent beams."[5] This requirement seems unnecessary or inapplicable to the VHF Hosted Payload, which is a receive-only payload in the Mobile-Satellite Service that creates no new RF transmissions and simply receives existing signals being transmitted by otherwise-authorized maritime transmitters. However, the VHF Hosted Payload effectively achieves the requirement of full frequency reuse through its design, which enables it to distinguish between ship-based transmitters operating on the same frequencies.

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[5] 47 C.F.R. § 25.210(f).

The VHF Hosted payload has two antenna beams which operate on the same frequencies with the same polarization. These two beams are not independent beams and have no polarization discrimination between the two beams. The two beams are used to discriminate among terrestrial mobile stations and mobile earth stations, mobile earth stations using these two frequencies, and the unallocated ASM, DSC and maritime distress channels. To the extent that a waiver is required of this default rule, Iridium requests a waiver of Section 25.210(f) because the two beams are specifically used to discriminate between mobile earth station transmissions using the same frequencies.

5. §§ 25.210(i)(1) & 25.210(i)(2).

Sections 25.210(i)(1) and (2) are additional Fixed-Satellite Service rules that seem inapplicable to the receive-only MSS payload that is the subject of this amendment. The rules require FSS space station antennas to provide specified cross-polarization in their primary coverage areas.[6] The VHF Hosted Payload space station antennas do not have nor use cross polarization in the primary coverage area. To the extent that a waiver is required of this default rule, Iridium requests a waiver of 25.210(i). The VHF Hosted Payload uses other techniques to discriminate between mobile earth stations on these frequencies. Therefore cross polarization is not relevant to the use of these frequencies by the VHF Hosted Payload receiver system.

6. § 25.142(b)(2).

Section 25.142(b)(2) sets out procedures and requirements related to coordination with NTIA and the Interdepartment Radio Advisory Committee (IRAC) for protection of Federal government users.[7] The VHF Hosted Payload system is a receive-only system. It receives the same AIS signals at the Iridium satellites that are transmitted by ship-based antennas for reception by the terrestrial AIS system. Since there are no new space-to-earth transmissions contemplated by this amendment, there is no potential for harmful interference to Federal government users. Therefore coordination with NTIA/IRAC should be unnecessary or a pro forma exercise.

7. § 25.285 Operation of MSS and ATC transmitters or transceivers on board civil aircraft.

This rule section seems to be directed to mobile earth station ***transmitters and transceivers***. Iridium's amendment is limited to the VHF Hosted Payload space station ***receivers***. Section 25.285, therefore, appears to be inapplicable to Iridium's amendment.

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[6] 47 C.F.R. § 25.210(i)(1)-(2).

[7] 47 C.F.R. § 25.142(b)(2).

8. § 25.287 Requirements pertaining to operation of mobile stations in the NVNG, 1.5/1.6 GHz, 1.6/2.4 GHz, and 2 GHz Mobile-Satellite Service bands.

The channels 161.975 and 162.0125 MHz are allocated to the maritime mobile and mobile satellite service (Earth-to-Space) solely for the Automatic Identification System.[8] The mobile stations transmit the AIS signal independently of receipt of the signal at the VHF Hosted Payload at the Iridium satellite. The VHF Hosted Payload system is a passive receiver of these signals and does not control the mobile station AIS transmissions in any way. No new mobile earth stations are being requested or will be authorized pursuant to this amendment. To the extent necessary, Iridium requests a waiver of this default rule since the satellite component of the AIS is designed to operate passively and independent of the control of the AIS transmissions.

[8] *See* 47 C.F.R. § 2.106 n. US52, RR 5.228C.

APPENDIX A

Representative Contour Maps
Representative VHF Receiver Hosted Payload Footprints

Altitude = 781 km, User Elevation Mask = 5 deg above horizon

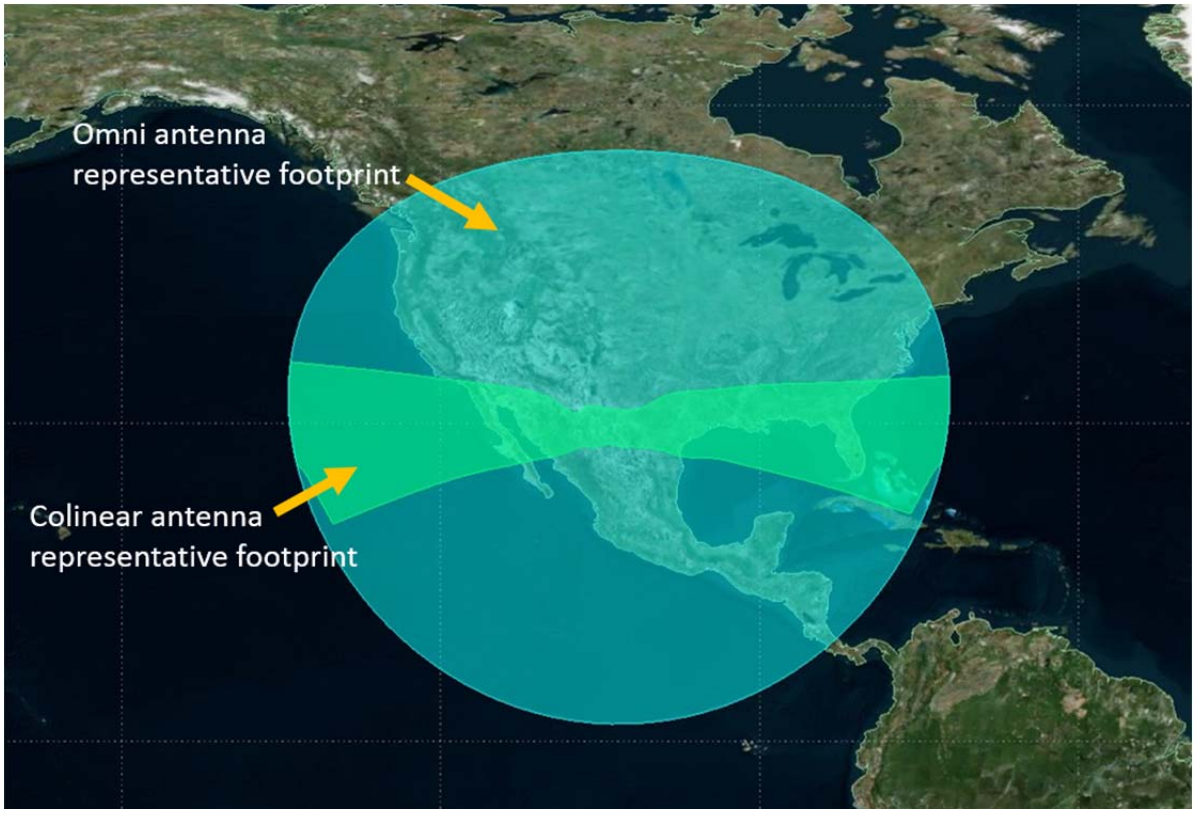
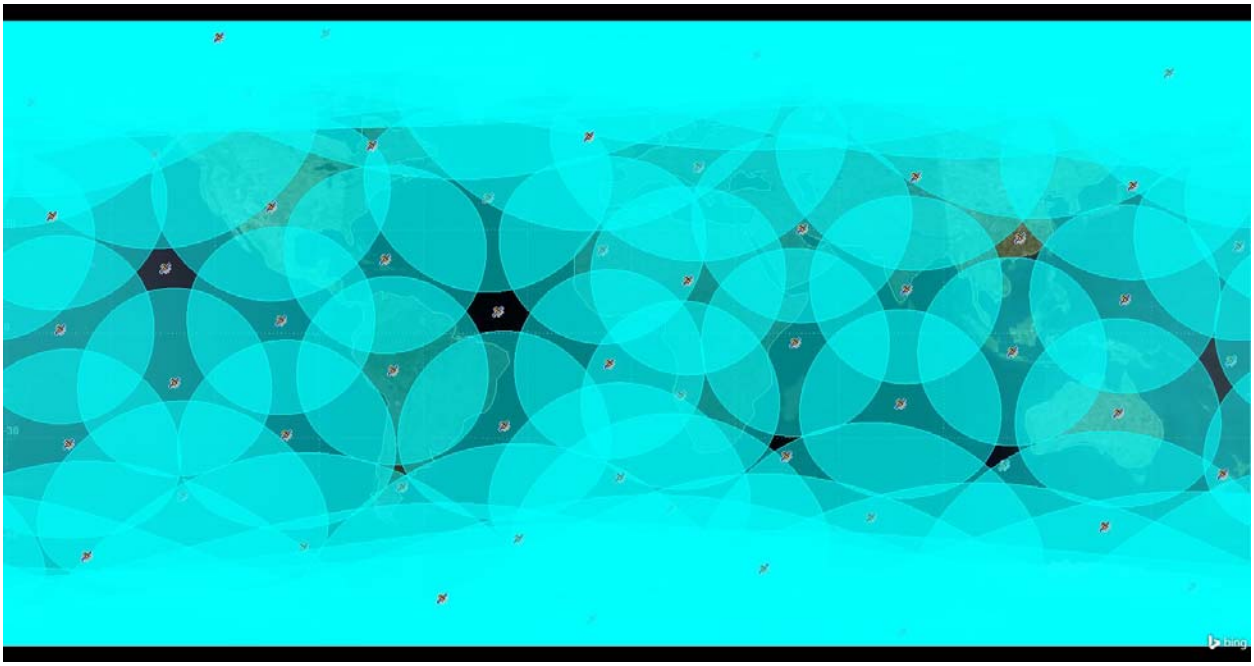


Figure 105



Representative VHF receiver hosted payload constellation footprints

Figure 106

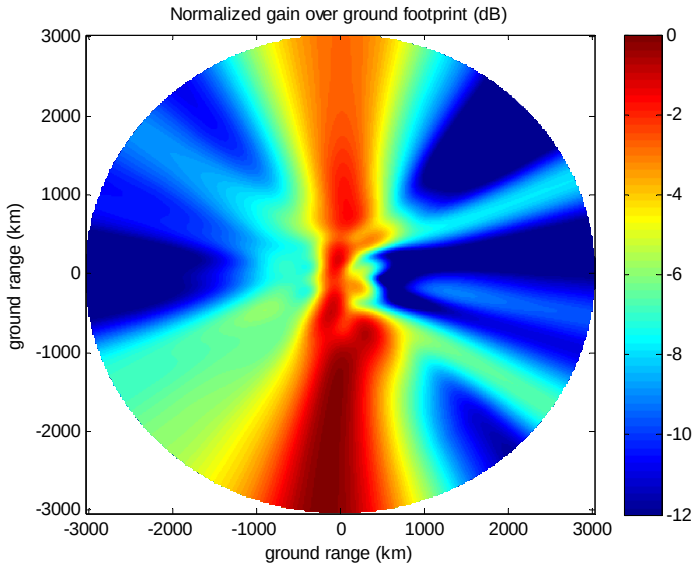


Figure 107 VHF Collinear Antenna Pattern at 159 MHz

Peak Gain ≈ 4.5 dBi

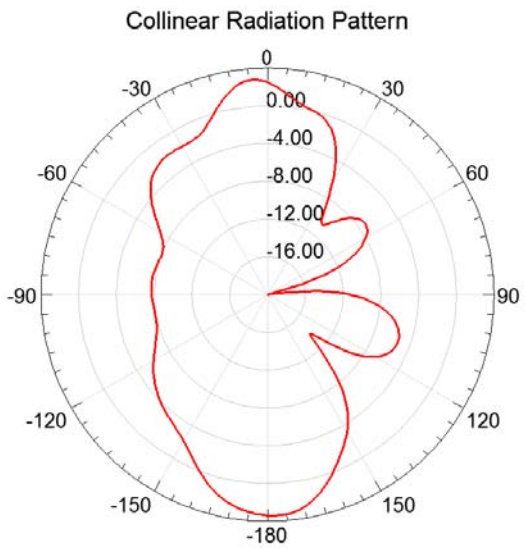


Figure108 VHF Collinear Antenna Pattern- Azimuth Cut at 159 MHz

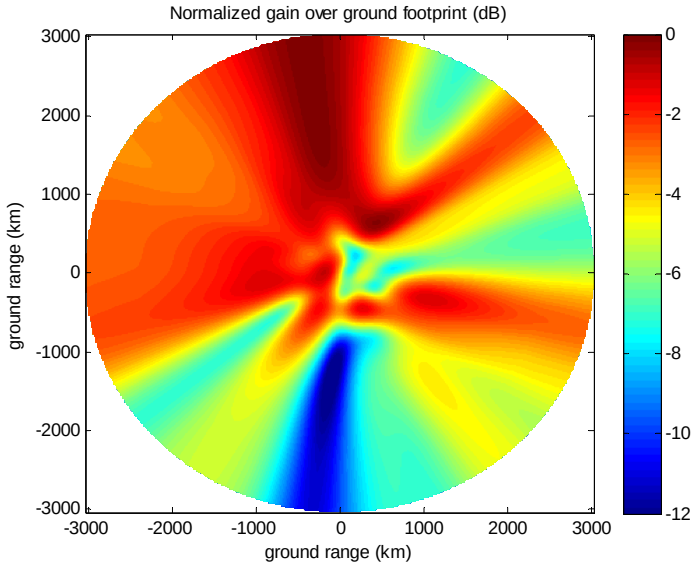


Figure 109 VHF Omnidirectional Antenna Pattern at 159 MHz

Peak Gain ≈ 4 dBi; Peak gain over FOV ≈ 3.3 dBi

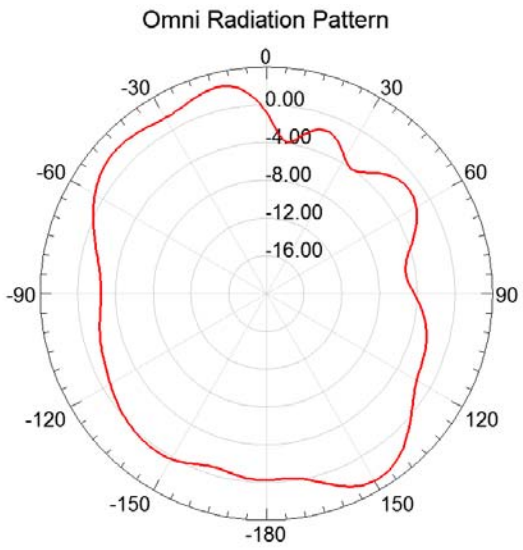


Figure 110 Omnidirectional pattern –Azimuth cut at 159MHz

APPENDIX B
Link Budgets

	Max. Value	Unit	Min. Value	Unit
Range Computation:				
Orbit Altitude	781	Km	781	Km
Elevation	0	deg	63	deg
Slant Range	3156	Km	788	Km
Modulation Characteristics:				
AIS: GMSK	9600	bps	9600	bps
LR AIS: GMSK	9600	bps	9600	bps
DSC: FSK	1200	bps	1200	bps
Maritime Distress: FSK	1200	bps	1200	bps
AIS Frequency:				
Frequency	162.0375	MHz	161.9375	MHz
Wavelength	1.85	m	1.85	m
LR AIS Frequency:				
Frequency	156.8375	MHz	156.7625	MHz
Wavelength	1.91	m	1.91	m
DSC Frequency:				
Frequency	156.5375	MHz	156.5125	MHz
Wavelength	1.92	m	1.92	m
Maritime Distress				
Frequency	156.7875	MHz	156.8125	MHz
Wavelength	1.91	m	1.91	m
AIS Transmitter Characteristics:				
Tx EIRP	15.29	dBW	6.01	dBW
LR AIS Transmitter Characteristics:				
Tx EIRP	15.29	7.51	6.01	dBW
DSC Transmitter Characteristics:				
Tx EIRP	15.29	dBW	15.29	dBW
Maritime Distress				
Tx EIRP	15.29	dBW	15.29	dBW
Path Characteristics (Same for all signals):				
Path Loss (Friis)	146.6	dB	134.9	dB

Absorption	0.03	dB	0.03	dB
Fade Margin	1.47	dB	1.47	dB
Total Loss	148.1	dB	136.4	dB
Rx Antenna 1 Characteristics:				
Rx Antenna Gain	1.5	dB	-4.8	dB
Rx Antenna Polarization Loss	3	dB	3	dB
Rx Pointing Loss	0.0	dB	0.0	dB
Net Rx Antenna Gain	-1.5		-7.8	
Rx Antenna 2 Characteristics:				
Rx Antenna Gain	4.5	dB	-9.2	dB
Rx Antenna Polarization Loss	3	dB	3	dB
Rx Pointing Loss	0	dB	0	dB
Net Rx Antenna Gain	1.5		-12.2	
Rx Noise Characteristics:				
Rx Antenna Temp	-173.98	dBm/Hz (290 deg K)	-173.98	dBm/Hz (290 deg K)
Rx System Noise Density (Rx System NF = 5.7dB)	-169.64	dBm/Hz	-169.64	dBm/Hz
System and Antenna Noise Density	-168.28	dBm/Hz	-168.28	dBm/Hz
Interference Noise Density	-198.60	dBm/Hz	-159.86	dBm/Hz
Total Rx Noise	-168.27	dBm/Hz	-159.28	dBm/Hz
Rx Signal Characteristics:				
Received Signal Power	-98.31	dBm	-109.59	dBm
Received Noise Power	-168.27	dBm/Hz	-159.28	dBm/Hz
Implementation Loss	1.00	dB	1.00	dB
Total Signal Power to Noise Density Ratio	69..96	dB-Hz	49.69	dB-Hz
AIS Link Margin:				
Required BER	3.00E-04		3.00E-04	
Required Eb/N0	8.4	dB	8.4	dB
Received Eb/N0	30.14	dB	9.86	dB
Link Margin	20.74	dB	0.46	dB

ENGINEERING CERTIFICATION

The undersigned hereby certifies to the Federal Communications Commission as follows:

(i) I am the technically qualified person responsible for the engineering information contained in the foregoing Engineering Statement Supplement,

(ii) I am familiar with Part 25 of the Commission's Rules, and

(iii) I have either prepared or reviewed the engineering information contained in the foregoing Engineering Statement Supplement, and it is complete and accurate to the best of my knowledge and belief.

Signed: */s/ Eric Petkus*

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Dated: October 22, 2015