REQUEST FOR EXPERIMENTAL SPECIAL TEMPORARY AUTHORITY

Harris CapRock Communications, Inc. ("Harris CapRock") hereby respectfully requests experimental special temporary authority ("STA") to operate a total of up to six (6) earth stations at two separate test sites located in Palm Bay (Melbourne), Florida and Houston, Texas, with a maximum of three (3) earth stations at each test site. Harris CapRock is developing and testing new earth stations to communicate with the Ka-band non-geostationary satellite orbit ("NGSO") fixed-satellite service ("FSS") system operated by O3b Limited ("O3b"), which has been previously authorized by the FCC to communicate with earth stations located in the United States. In this filing, Harris CapRock seeks an experimental STA for the period between January 6, 2015 and June 30, 2015.

Harris CapRock will operate the new circular 2.4m Ka-band terminal (Model ST5000-2.4) for non-commercial development, testing and demonstration purposes with the O3b system at the Melbourne and Houston test locations. Harris CapRock will evaluate antenna performance, including tracking characteristics, throughput, link analyses and potential applications of the antenna with the O3b system, including interactive video teleconferencing, interactive access to complex web content from the Internet and very large file transfers.

Grant of the requested authority would serve the public interest by allowing Harris CapRock to develop a new line of O3b antennas that could greatly benefit government and commercial customers. Moreover, the proposed experimental operations raise no concern regarding potential interference to co-frequency systems and services, will be conducted on an unprotected, non-interference basis and will otherwise comply with Part 5 of the FCC Rules.

The O3b Satellite System

The new 2.4m earth stations will communicate with O3b's UK-authorized, Ka-band NGSO FSS system.[1] The Commission has granted O3b authority for gateway and other earth station operations in the United States.[2] O3b has filed a Letter of Intent ("LOI") to access the

[1] O3b's system includes four satellites launched on June 25, 2013, and a second tranche of four satellites launched on July 10, 2014. O3b's third tranche of satellites is scheduled for launch on December 18, 2014.

[2] For example, in September 2012, the Commission granted O3b a license to operate a gateway earth station in Haleiwa, Hawaii, to communicate with its NGSO FSS system. *See* FCC File No. SES-LIC-20100723-00952 (granted September 25, 2012). In June 2013, the Commission granted O3b a license to operate a second gateway in the United States, located in Vernon, Texas. *See* FCC File No. SES-LIC-20130124-00089 (granted June 20, 2013). In May 2014, the Commission granted O3b a blanket license to operate maritime earth stations. *See* FCC File No. SES-LIC-20130528-00455 (granted May 13, 2014).

U.S. market with its third tranche of satellites and to consolidate its market access authority.[3] O3b has also been granted numerous STAs for earth stations to communicate with the O3b system, including specifically in Houston, Texas, and Melbourne, Florida, using the frequencies requested herein.[4]

Because this application requests experimental authority for antenna development purposes only, Harris CapRock hereby incorporates by reference the relevant satellite and market access-related information supporting these prior grants.[5] As a result, although general background information is provided, this application focuses on the technical characteristics of the new ST5000-2.4 terminal and confirmation that the antenna will be operated for test purposes on an unprotected, non-interference basis under Part 5 of the Rules.

Proposed Test Sites

The Palm Bay (Melbourne), Florida, test site is located at N 28.0309° and W -80.5988°. The Houston, Texas, test site is located at N 29.5984° and W -95.3471°. As noted above, earth stations have been previously authorized to communicate with the O3b system at these locations. In addition, as discussed in the following section, no coordination with other co-frequency systems or services is required. Nonetheless, given the experimental nature of the operations proposed herein, Harris CapRock agrees to accept all interference from co-frequency operations and will immediately suspend operations in the event of interference to other systems and services.

The 2.4m antenna terminals will be mounted on a temporary fixed platform in a controlled test area where general public access is prohibited. Although the pointing angle of the antennas will change as O3b's in-orbit satellites are tracked, the platform will remain stationary during the demonstration. Only trained operators and technicians will be permitted to access the terminals, and specific instruction will be provided with respect to radiofrequency hazard characteristics of the antenna.

Proposed Spectrum Use

Harris CapRock's proposed earth station operations in shared bands are consistent with the Commission's rules and policies. Harris CapRock first notes that O3b has completed all necessary coordination with U.S. government satellite networks operating in the Ka-band, including GSO and NGSO networks, as well as their associated specific earth stations filed under

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[3] *See* O3b Limited, Call Sign S2935, File No. SAT-LOI-20141029-00118.

[4] *See., e.g.*, O3b Limited, File Nos. SES-STA-20140819-00666 (Houston, TX), SES-STA-20140731-00627, SES-STA-20140429-00314 and SES-STA-20130620-00515 (Melbourne, FL).

[5] *See, e.g., id.* and related file numbers. Harris CapRock respectfully requests leave to supplement this filing with O3b satellite or market access information should the FCC deem such information necessary or appropriate to support grant of this experimental STA application.

9.7A and 9.7B of the ITU Radio Regulations through other administrations. O3b has also completed coordination, according to U.S. footnote 334 of the FCC Table of Frequency Allocations, with the U.S. government, and this US334 coordination agreement specifically provides for additional earth stations in U.S. territory operating with O3b's satellites.

Harris CapRock will limit terminal uplink transmission to the 28.6-29.1 GHz band. Under the Commission's Ka-band plan, this band may be used on a primary basis by NGSO FSS systems.[6] Harris CapRock recognizes, however, that operations under the requested STA will be on an unprotected, non-harmful interference basis. The experimental development, test and demonstration operations will adequately protect allocated services operating in this band.

The proposed demonstrations will not cause any interference into or require protection from any co-frequency GSO satellites. As previously shown by O3b,[7] there is an inherent angular separation between the O3b system orbit and the GSO arc from the perspective of earth stations located away from the equator. The Houston, Texas, and Melbourne, Florida, test sites are located further north in latitude than the O3b Hawaii gateway, which results in an even greater angular separation between the O3b and geostationary orbits as viewed from the Earth. This means that the angular separation between the O3b satellites and GSO arc from these locations will be greater than the 7° separation accepted by the Commission when it approved O3b's Hawaii gateway. This ensures that GSO FSS systems will be adequately protected.

Potential interference from the proposed operations into U.S. terrestrial fixed service ("FS") receivers in the 28.6-29.1 GHz band is a non-issue because there is no allocation in the Commission's Ka-band plan for FS stations operating in this band in the United States.

With respect to sharing with other Ka-band NGSO systems, Harris CapRock notes that there are no planned NGSO systems contemplated for deployment throughout the duration of the contemplated operations. Moreover, the O3b system is capable of sharing with future NGSO networks operating in the same frequency bands and, therefore, will not preclude additional entry by future NGSO licensees.[8] Thus, the proposed experimental operations can be authorized on an unprotected, non-interference basis under Part 5 of the Rules.

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[6] *See In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, 11 FCC Rcd. 19005, ¶¶ 59-62 and 79 (1996). *See also In the Matter of Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use*, 15 FCC Rcd. 13430, ¶ 28 (2000).

[7] *See* O3b Hawaii License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.

[8] First, the entire O3b constellation will occupy a single circular orbit above the Earth's Equator, which enables an angular separation to be maintained between O3b communications links and the links of other NGSO systems using different orbits. Second, the O3b satellite system uses a

Although not part of the requested experimental authority, Harris CapRock notes that its proposed receive operations are also on an unprotected, non-interference basis only. Under the Commission's Ka-band plan, the 18.8-19.3 GHz band may be used on a primary basis by licensed NGSO FSS systems.[9] This band is not allocated for GSO FSS networks.[10] Nevertheless, the proposed demonstrations will not cause any interference into, or require protection from, any co-frequency GSO satellites. Furthermore, FS stations operating in the 18.8-19.3 GHz band are no longer co-primary with FSS users in this band.[11] However, because the experimental operations proposed herein will be conducted on an unprotected, non-interference basis, Harris CapRock agrees to accept any interference that its terminals may receive from FS transmissions in the 18.8-19.3 GHz band.

Earth Station Technical Parameters

The new ST5000-2.4 terminal is comprised of a 2.4m circular reflector antenna, an antenna positioner, and an antenna control module. The antenna positioner and control module are the same as those used in Harris CapRock's SpaceTrack 4000 series of stabilized antennas. The SpaceTrack 4000 has been previously licensed by the FCC in C-band and Ku-band ESV configurations and has years of proven experience in the field. Not only has the SpaceTrack 4000 been deployed in 2.4m configurations, but the operating environment in the ESV maritime context is far harsher than the proposed fixed temporary operations – with higher scan rates, torque, jarring, etc. – and there have been no reported cases of interference due to antenna misalignment or similar factors. Thus, the FCC can be assured that ST5000-2.4 will operate as designed to avoid potential interference to adjacent satellites.

Tracking the predictable O3b satellites as they fly in their equatorial path from fixed locations is quite straightforward. Although the ST5000-2.4 terminal is a full-motion stabilized antenna, the operational range for communications is towards the southern sky. For example, for the Melbourne, FL test site, the O3b satellites rise at approximately 240° azimuth and set at approximately 130° azimuth. The elevation angle for communications range from 24° on the rising satellite to 43.5° at zenith and then down to 28° for the setting satellite. Thus, a minimum elevation angle of 20° is a conservative assumption. The operational values for the Houston, Texas, test site are similar to those for the Melbourne, Florida, site.

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combination of multiple tracking antennas and satellite diversity to avoid interference from its system into other NGSO systems and from other NGSO systems into O3b. This further enables the use of angular discrimination to facilitate spectrum sharing, while providing a mechanism for interference avoidance in the rare event that an O3b earth station is pointed at an O3b satellite that is in-line with a satellite of another NGSO system.

[9] *See supra* n. 6.

[10] *See* id.

[11] *See* 47 C.F.R. § 101.85(b)(2).

Harris CapRock's ST5000-2.4 terminal is designed to meet the FCC's ESV operational requirements, which have been extended by analogy to full-motion antennas communicating with the O3b system. These parameters include: (i) maintaining off-axis EIRP to the levels set forth in the applicable FCC mask (in the case of Ka-band, Section 25.138); (ii) pointing accuracy of 0.2° or better; (iii) automatic cessation of emissions within 100 ms if pointing offset exceeds 0.5°; and (iv) transmissions will not resume until pointing accuracy is within 0.2°. The technical characteristics of the terminal are set forth in the follow tables.

SUMMARY OF TECHNICAL PARAMETERS – ST5000-2.4

Antenna diameter	2.4m
Type of Antenna	2.4m circular reflector
Peak Power (SSPA)	40 watts
Transmit Bandwidth	1 MHz to 216 MHz
Transmit Gain	54.7 dBi
EIRP	68.9 dBW
Data Rate	160 Mbps Tx/ 300 Mbps Rx
Emission Designators	1M00G7D to 216MG7D
Transmit Polarization	Horizontal or Vertical
Transmit Max PSD	46.4 dBW/4kHz
Transmit Beamwidth	.14 degrees
Receive G/T	26.5 dB/K
Receive Bandwidth	Up to 216 MHz
Receive Polarization	LHCP and RHCP

ANTENNA CONTROL PARAMETERS - ST5000-2.4

Azimuth	Continuous coverage over 360º
Elevation	0 to 90º antenna elevation
Position accuracy	0.2º (auto-disable at 0.5 º offset)
Tracking capability	8º/sec

Additional information regarding the ST5000-2.4 terminal, including antenna performance plots (compliance with the FCC's off-axis EIRP mask), link budgets, and a radiofrequency hazard assessment are included as attachments hereto.

Stop Buzzer Contact and Other Information

Although Harris CapRock will coordinate closely with O3b in the context of antenna development, testing, and demonstration, the proposed experimental operations will be subject to the ultimate direction and control of Harris CapRock. The Harris CapRock point of contact with the authority to suspend immediately the proposed ST5000-2.4 terminal operations is:

Mike Horn
Harris CapRock Communications
1025 West NASA Blvd.
Melbourne, FL USA 32919
Phone: 321-724-3384
Mobile: 321-258-4414
Text: 3212584414@text.att.net
E-mail: mhorn01@harris.com

The secondary point of contact for the proposed experimental operations is:

Harris CapRock Network Control Center
Managed Network Services 24x7 support
4400 S. Sam Houston Pkwy, E.
Houston, Texas 77046
Office: (832) 668-2775
Fax: (713) 987-2894
Email Address: hcc-hou-csc@harris.com

The following annexes contain additional technical information relating to the proposed experimental operations:

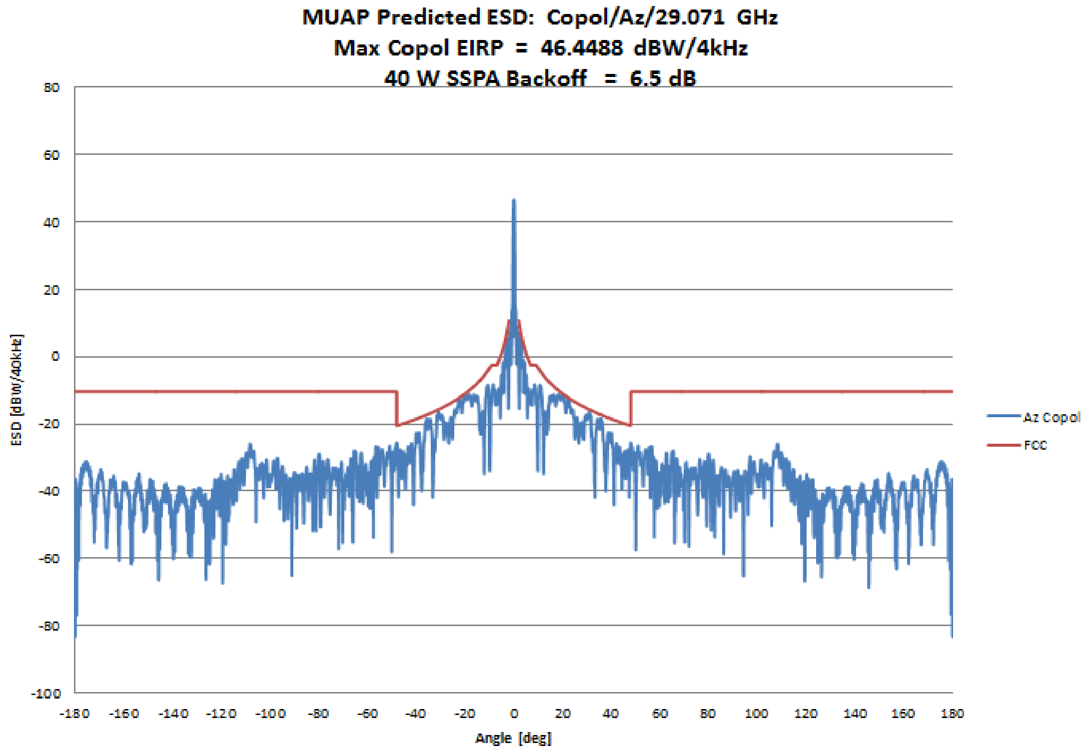
- Annex 1 – Antenna Performance Plots (demonstrating compliance with the FCC's Ka-band, off-axis EIRP spectral density mask, including co-pol and cross-pol at +/-180º, +/-30º, +/-10º and various transmit frequencies).
- Annex 2 - Link Budgets (various forward and return link budgets for the ST5000-2.4 terminal).
- Annex 3: Radiation Hazard Study (establishing near-field and far-field region distances). Harris CapRock will follow standard industry procedures to mitigate potential radiation hazards to personnel in controlled environments. (The terminals do not transmit in uncontrolled areas at Harris CapRock test facilities.)
- Annex 4 – SpaceTrack 4000 Product Brochure (outlining technical characteristics of the proven 4000 series of stabilized antennas).

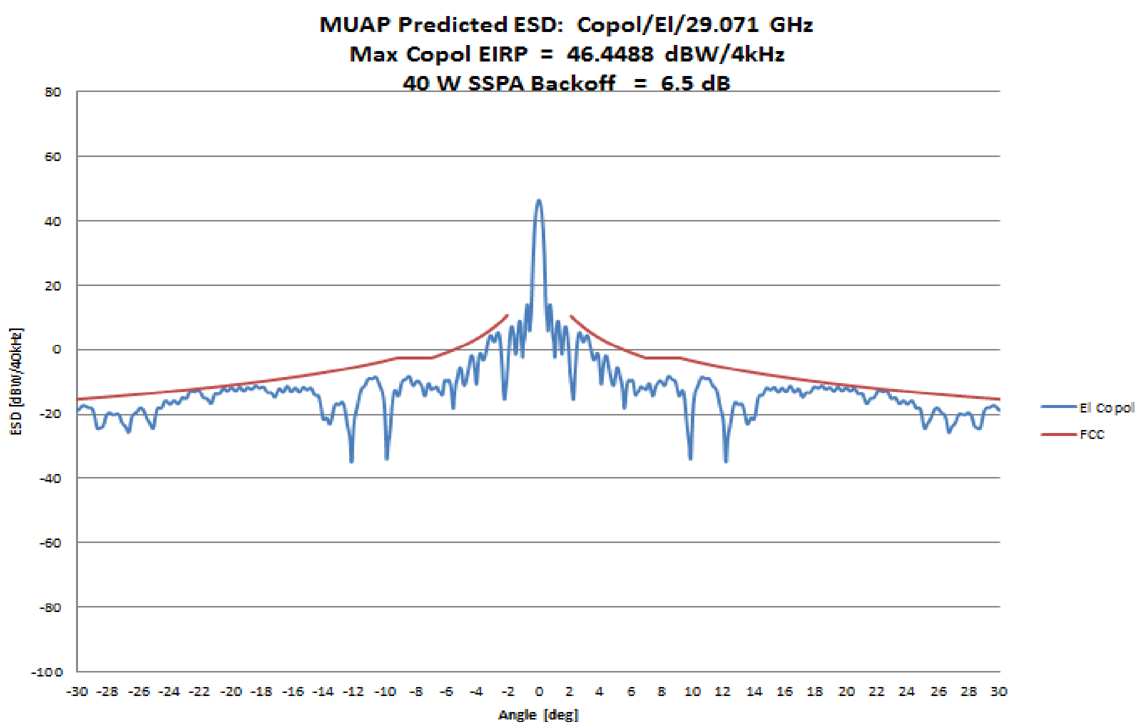
Conclusion

The requested experimental STA will allow Harris CapRock to develop, test and demonstrate the operational capabilities of its new 2.4m terminal with the O3b system, and will not result in harmful interference to or require protection from other authorized spectrum users. Accordingly, the proposed operations are consistent with Part 5 of the FCC's rules and within the public interest. Harris CapRock respectfully requests that the experimental STA be granted for the period from January 6, 2015 to June 30, 2015.

Annex 1 – Antenna Performance Plots

Demonstration of Compliance with FCC Ka-band Off-Axis EIRP Mask (Co-pol and Cross-pol)


MUAP Predicted ESD: Copol/Az/29.071 GHz
Max Copol EIRP = 46.4488 dBW/4kHz
40 W SSPA Backoff = 6.5 dB
ESD [dBW/40kHz]
Angle [deg]
Az Copol
FCC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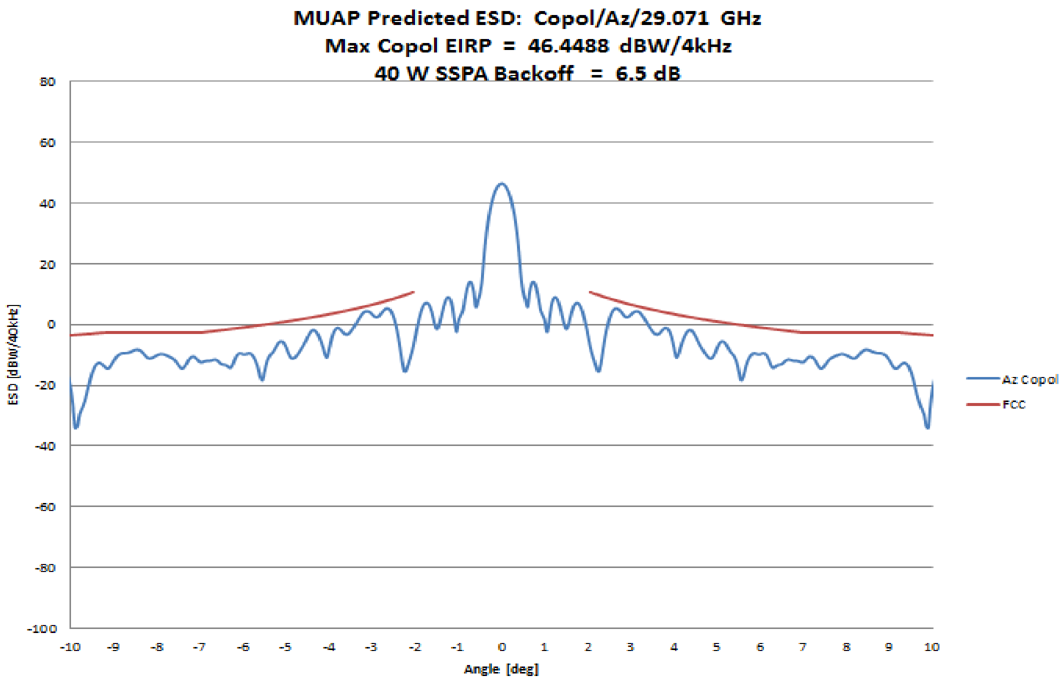
Max Copol EIRP = 46.4488 dBW/4kHz
40 W SSPA Backoff = 6.5 dB
ESD [dBW/40kHz]
Angle [deg]
El Copol
FCC


MUAP Predicted ESD: Copol/Az/29.071 GHz
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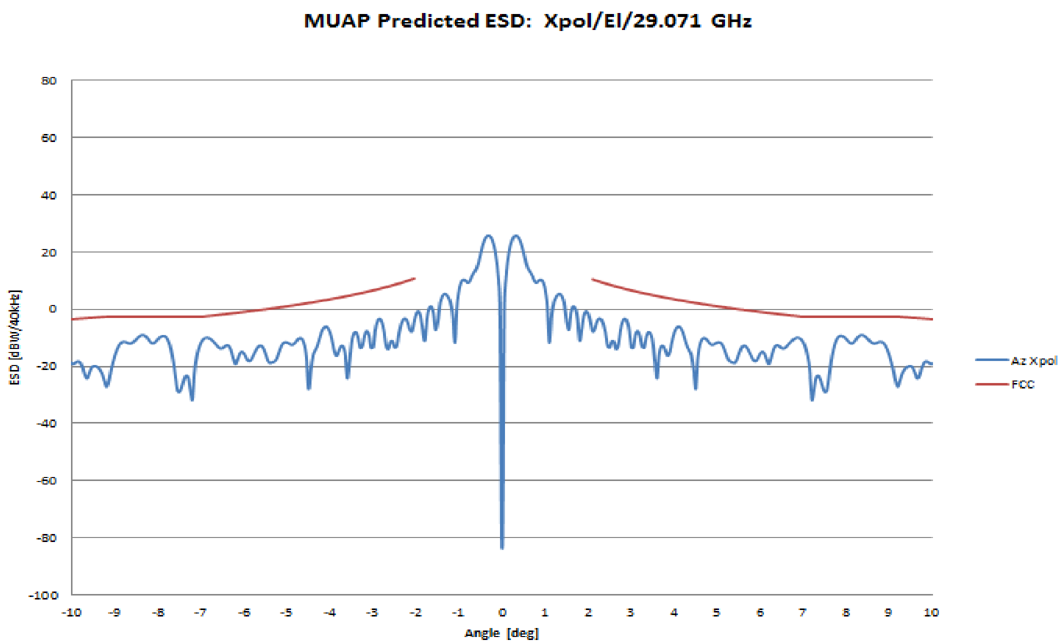
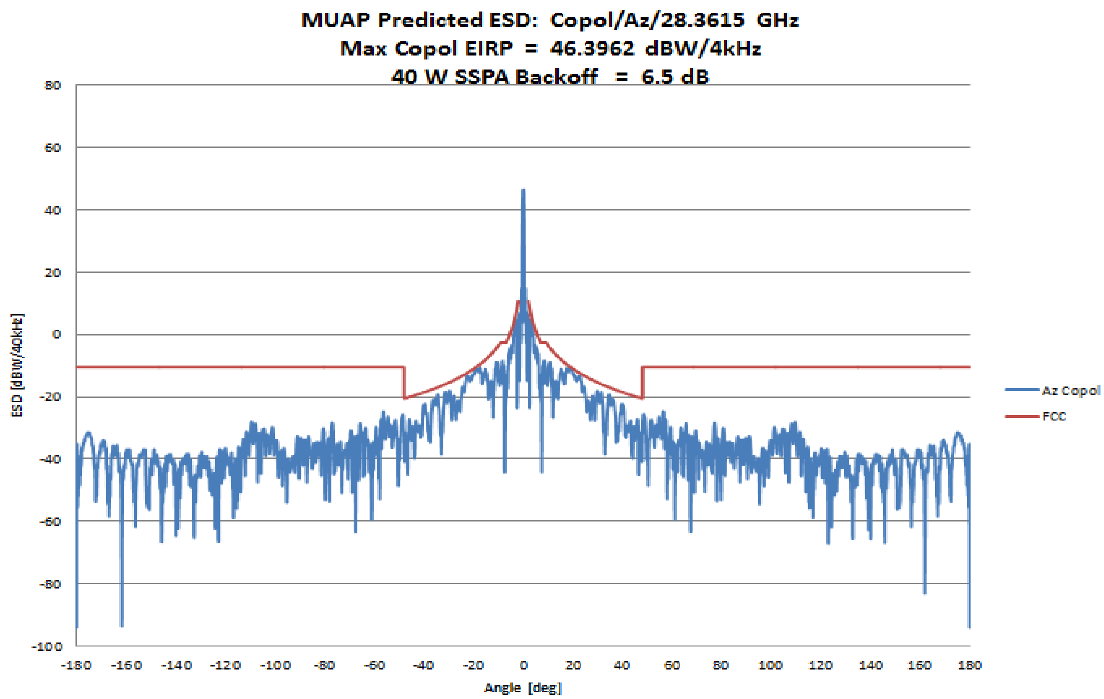
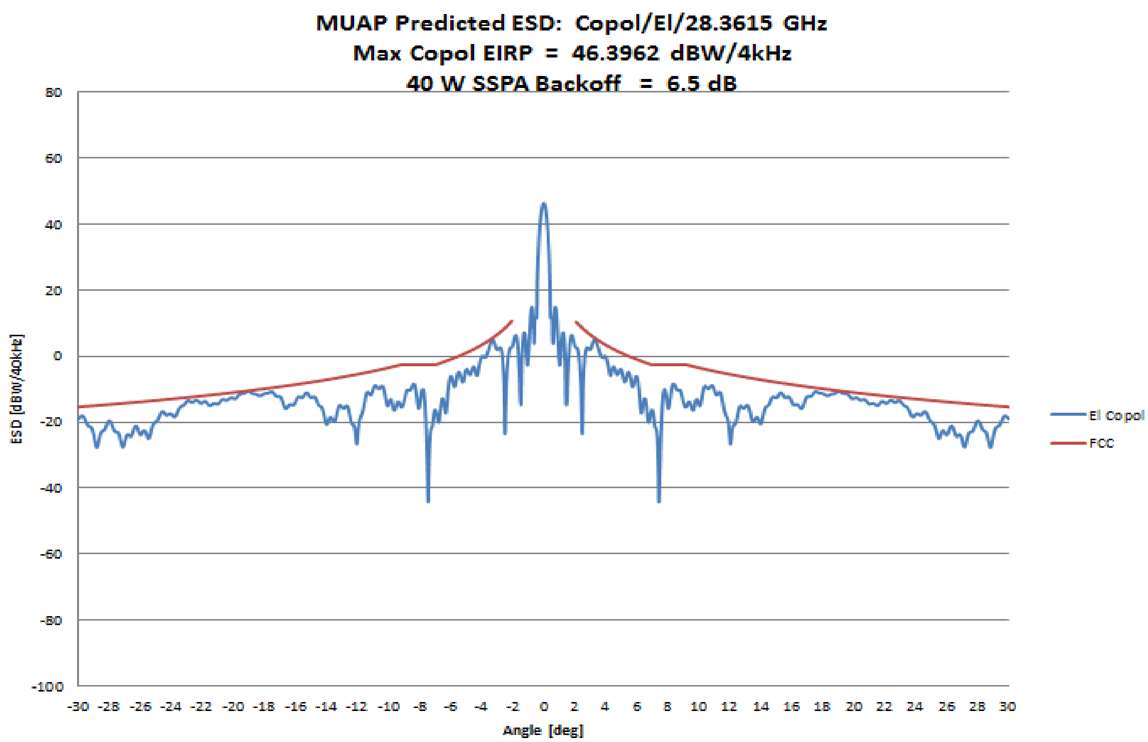
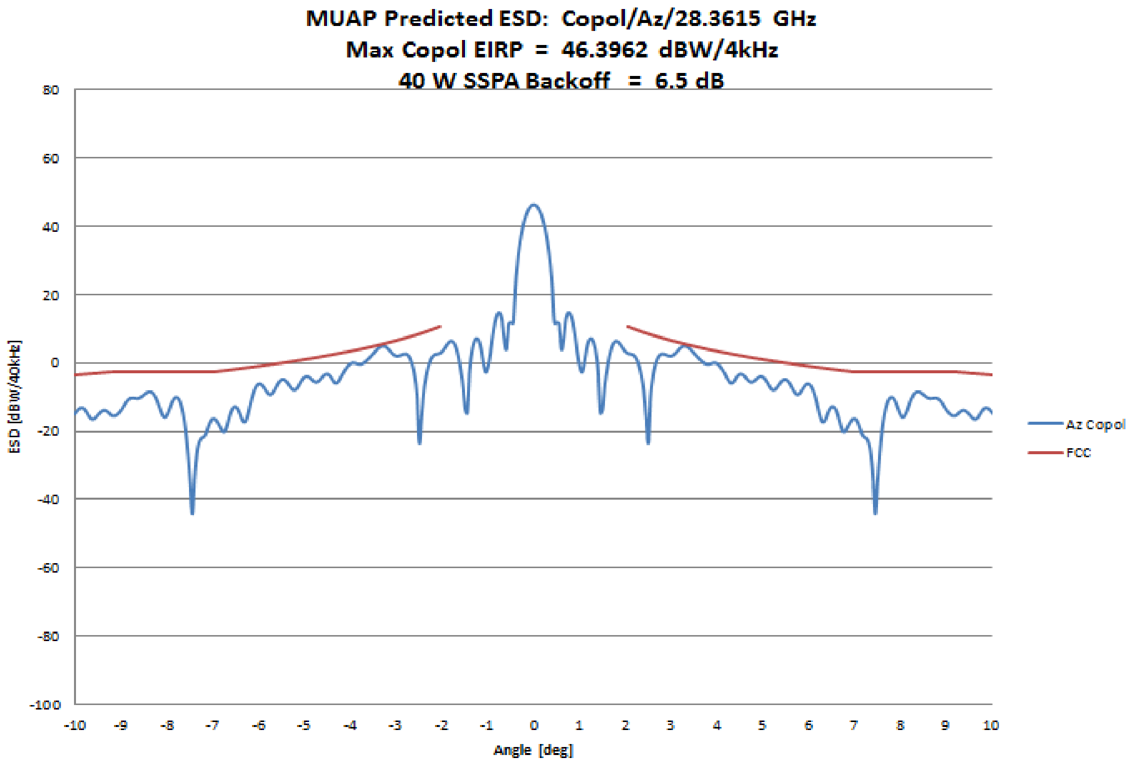
40 W SSPA Backoff = 6.5 dB
ESD [dBW/40kHz]
Angle [deg]
Az Copol
FCC


MUAP Predicted ESD: Xpol/El/29.071 GHz
ESD [dBW/40kHz]
Angle [deg]
Az Xpol
FCC


MUAP Predicted ESD: Copol/Az/28.3615 GHz
Max Copol EIRP = 46.3962 dBW/4kHz
40 W SSPA Backoff = 6.5 dB
ESD [dBW/40kHz]
Angle [deg]
Az Copol
FCC


MUAP Predicted ESD: Copol/El/28.3615 GHz
Max Copol EIRP = 46.3962 dBW/4kHz
40 W SSPA Backoff = 6.5 dB
ESD [dBW/40kHz]
Angle [deg]
El Copol
FCC


MUAP Predicted ESD: Copol/Az/28.3615 GHz
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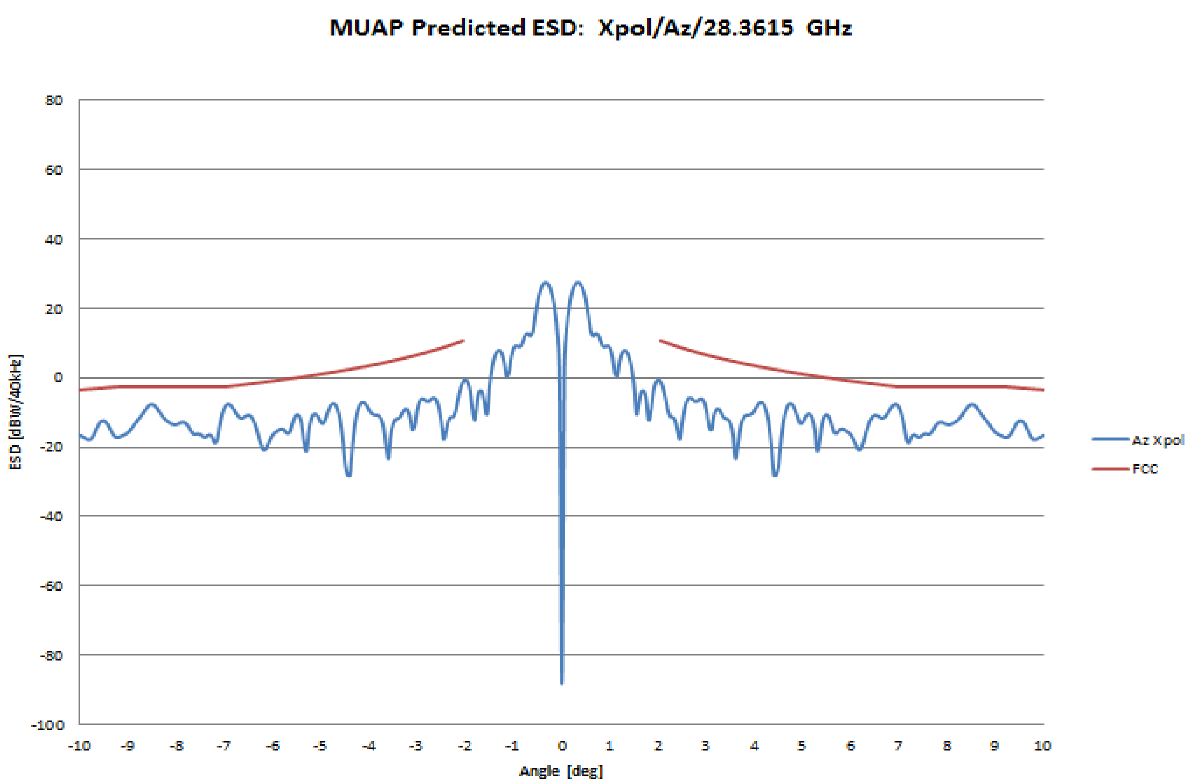
40 W SSPA Backoff = 6.5 dB
ESD [dBW/40kHz]
Angle [deg]
Az Copol
FCC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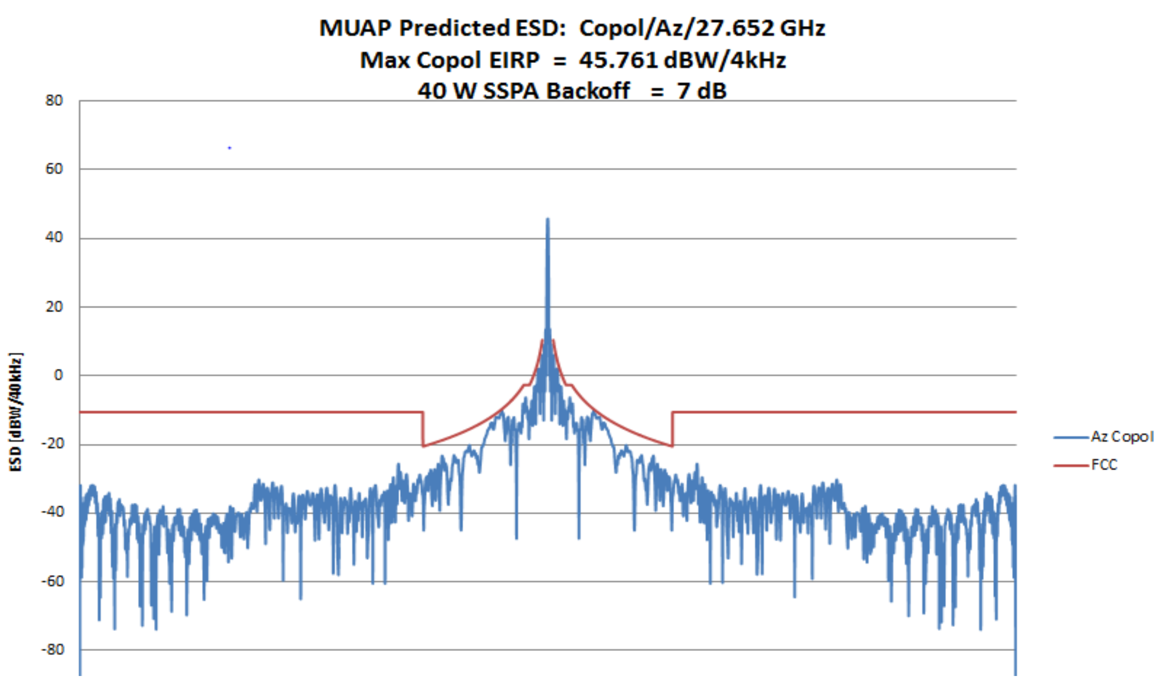
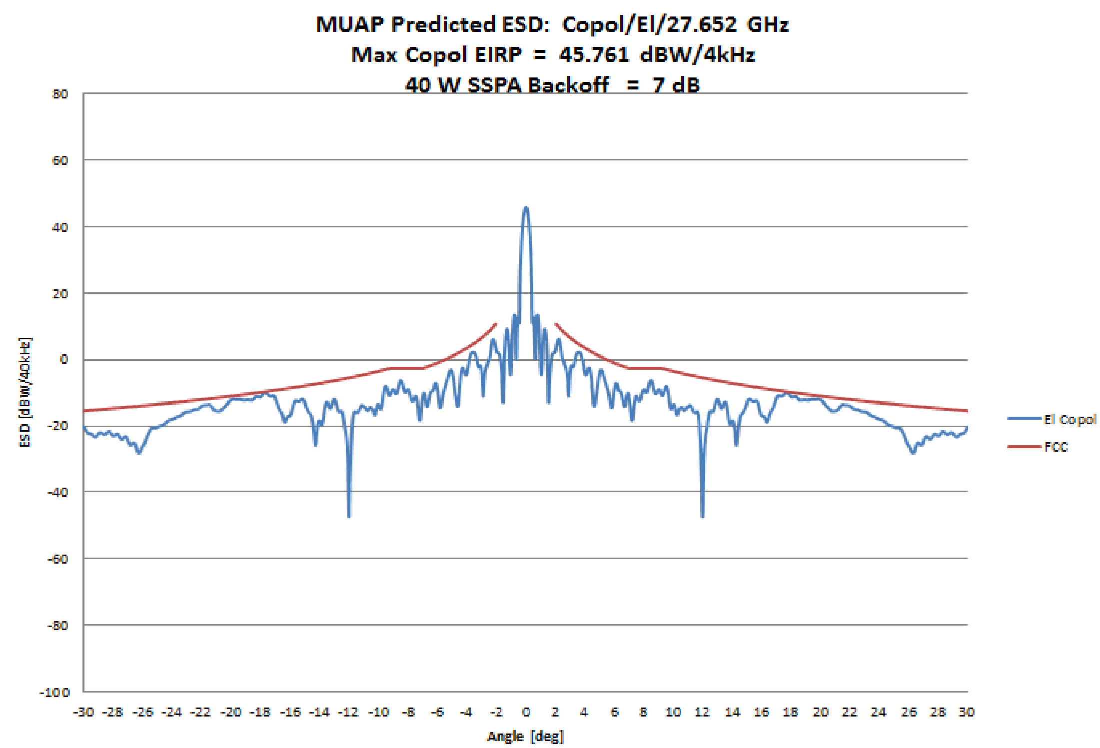
ESD [dBW/40kHz]
Angle [deg]
Az Xpol
FCC


MUAP Predicted ESD: Copol/Az/27.652 GHz
Max Copol EIRP = 45.761 dBW/4kHz
40 W SSPA Backoff = 7 dB
ESD [dBW/40kHz]
80
60
40
20
0
-20
-40
-60
-80
Az Copol
FCC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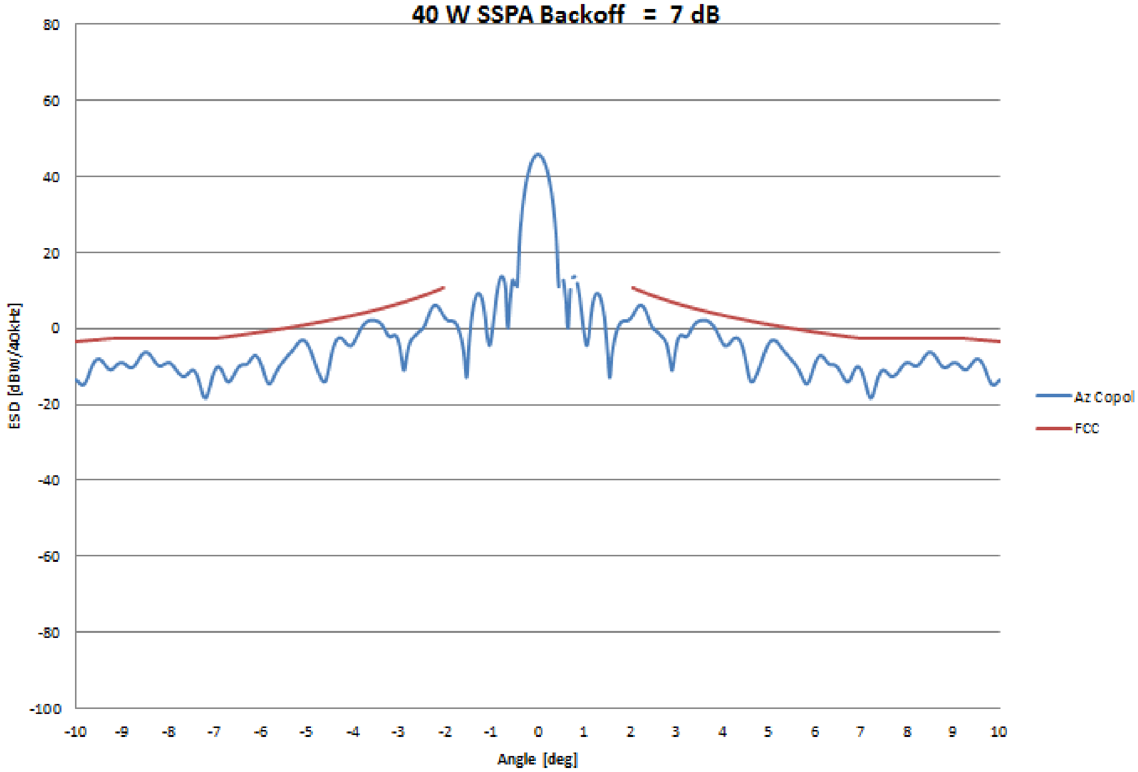
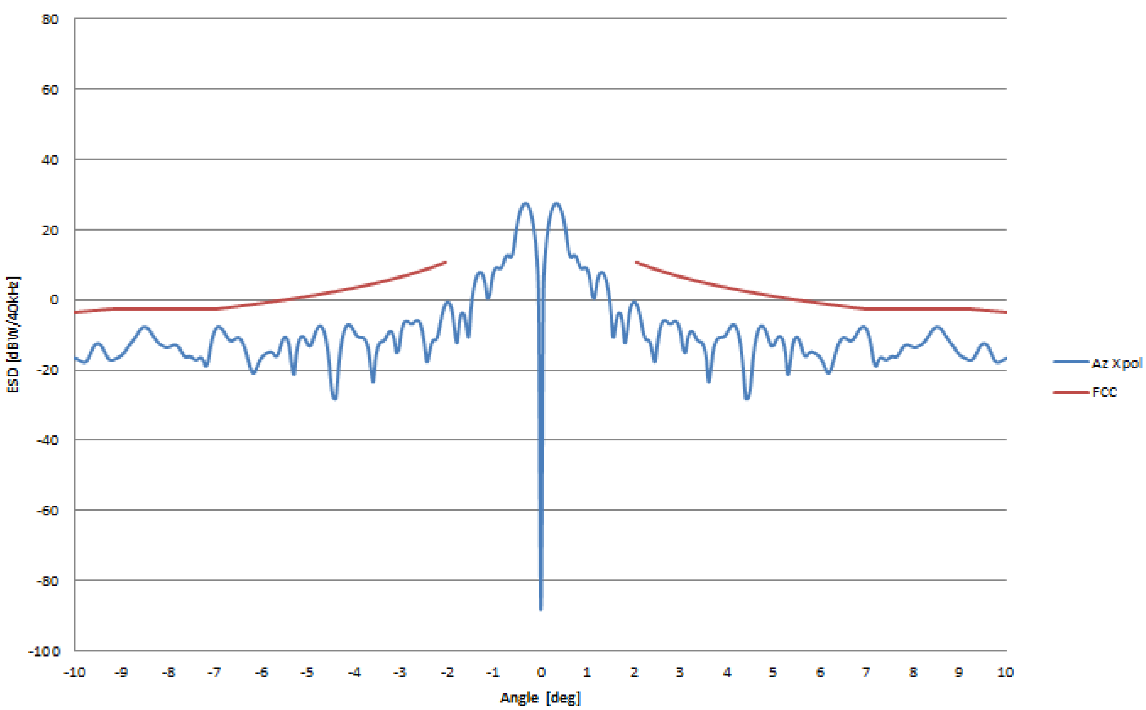
ESD [dBW/40kHz]
80
60
40
20
0
-20
-40
-60
-80
-100
-30 -28 -26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Angle [deg]
El Copol
FCC

MUAP Predicted ESD: Copol/Az/27.652 GHz
Max Copol EIRP = 45.761 dBW/4kHz
40 W SSPA Backoff = 7 dB



MUAP Predicted ESD: Xpol/Az/28.3615 GHz



ANNEX 2 – Link Budgets

Link Budget: Return (Clear Sky)

O3b Networks Link Analysis - Tier2 Service for Melbourne Beach/U.S.A.			
ECM Link Budget Rpt - 11/19/2014		**Tier2**	**Tier2**
Parameters	Unit	**Clear Sky**	
Ground parameters		**Teleport**	**Telco**
Location		Vernon/U.S.A.	Melbourne Beach/U.S.A.
Latitude	(deg)	34.16	28.09
Longitude (East)	(deg)	260.71	279.39
E/S Range to SV	(km)	10166.69	9311.20
E/S Elevation to SV	(deg)	29.99	43.30
E/S Altitude	(km)	0.00	0.00
SV Beam Identifier	(#)	12	
Telco Offset to Beam Center	(km)	0.27	
Modulation Parameters		**Return**	
Enter Reciever	Type	MEOLink	
Percentage of Bandwidth	(%)	50%	
Allocated Bandwidth	(MHz)	108	
Channel Symbol Rate	(Msps)	90	
Channel Modulation Type		8PSK	
Channel FEC Rate		0.60	
Channel Throughput	(Mbps)	159.60	
Uplink		**Return**	
E/S Carrier Frequencies	(MHz)	28020	
E/S Tx HPA Power Level	(W)	40	
E/S Tx OBO	(dB)	-9	
E/S Tx Antenna Gain (2.4m)	(dB)	54.67	
E/S Tx EIRP Per Channel	(dBW)	58.80	
E/S Tx RF Link Availability	(%)	Clear	
E/S Tx Spreading Loss	(dB)	-151.13	
Satellite		**Return**	
SV Rx G/T	(dB/K)	5.57	
SV Tx OBO	(dB)	-15.81	
SV Tx EIRP Per Channel/Carrier	dBW	32.44	
Downlink		**Return**	
E/S Rx Carrier Frequency	(MHz)	18220	
E/S Rx Rf Link Availability	(%)	Clear	
E/S Rx Antenna Gain (7.3m)	(dBi)	61.91	
E/S Rx Effective G/T	(dB/K)	40.44	
Total Link		**Return**	
Carrier/Noise Bandwidth	(dB)	45.00	
Carrier/Noise Uplink	(dB)	11.19	
Carrier/Noise Downlink	(dB)	23.08	
Carrier/Intermodulation Im (C/Im)	(dB)	25.00	
(C/N)- Total Actual (Es/No)	(dB)	10.39	
(C/N)-Total Required	(dB)	6.89	
(Eb/No)-Total Actual	(dB)	8.48	
(Eb/No)-Total Required	(dB)	8.48	
Excess Margin	(dB)	**3.50**	
Fade Margin	(dB)	**12.65**	

Link Budget: Return (Rain)

O3b Networks Link Analysis - Tier2 Service for Melbourne Beach/U.S.A.			
ECM Link Budget Rpt - 11/19/2014		**Tier2**	**Tier2**
Parameters	Unit	**Rain Up**	
Ground parameters		**Teleport**	**Telco**
Location		Vernon/U.S.A.	Melbourne Beach/U.S.A.
Latitude	(deg)	34.16	28.09
Longitude (East)	(deg)	260.71	279.39
E/S Range to SV	(km)	10166.69	9311.20
E/S Elevation to SV	(deg)	29.99	43.30
E/S Altitude	(km)	0.00	0.00
SV Beam Identifier	(#)	12	
Telco Offset to Beam Center	(km)	0.27	
Modulation Parameters		**Return**	
Enter Reciever	Type	MEOLink	
Percentage of Bandwidth	(%)	50%	
Allocated Bandwidth	(MHz)	108	
Channel Symbol Rate	(Msps)	90	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.66	
Channel Throughput	(Mbps)	118.37	
Uplink		**Return**	
E/S Carrier Frequencies	(MHz)	28020	
E/S Tx HPA Power Level	(W)	40	
E/S Tx OBO	(dB)	-3	
E/S Tx Antenna Gain (2.4m)	(dB)	54.67	
E/S Tx EIRP Per Channel	(dBW)	64.80	
E/S Tx RF Link Availability	(%)	99.254%	
E/S Tx Spreading Loss	(dB)	-151.13	
Satellite		**Return**	
SV Rx G/T	(dB/K)	5.57	
SV Tx OBO	(dB)	-19.42	
SV Tx EIRP Per Channel/Carrier	dBW	28.83	
Downlink		**Return**	
E/S Rx Carrier Frequency	(MHz)	18220	
E/S Rx Rf Link Availability	(%)	Clear	
E/S Rx Antenna Gain (7.3m)	(dBi)	61.91	
E/S Rx Effective G/T	(dB/K)	40.44	
Total Link		**Return**	
Carrier/Noise Bandwidth	(dB)	45.00	
Carrier/Noise Uplink	(dB)	7.59	
Carrier/Noise Downlink	(dB)	19.48	
Carrier/Intermodulation Im (C/Im)	(dB)	21.39	
(C/N)- Total Actual (Es/No)	(dB)	6.87	
(C/N)-Total Required	(dB)	4.34	
(Eb/No)-Total Actual	(dB)	6.38	
(Eb/No)-Total Required	(dB)	6.38	
Excess Margin	(dB)	**2.53**	
Fade Margin	(dB)	**9.13**	

Link Budget: Forward (1)

O3b Networks Link Analysis - Tier2 Service for Melbourne Beach/U.S.A.			
ECM Link Budget Rpt - 11/19/2014		**Tier2**	**Tier2**
Parameters	Unit	**Rain Up**	
Ground parameters		**Teleport**	**Telco**
Location		Vernon/U.S.A.	Melbourne Beach/U.S.A.
Latitude	(deg)	34.16	28.09
Longitude (East)	(deg)	260.71	279.39
E/S Range to SV	(km)	10166.69	9311.20
E/S Elevation to SV	(deg)	29.99	43.30
E/S Altitude	(km)	0.00	0.00
SV Beam Identifier	(#)	15	
Telco Offset to Beam Center	(km)	0.27	
Modulation Parameters		**Forward**	
Enter Reciever	Type	MEOLink	
Percentage of Bandwidth	(%)	100%	
Allocated Bandwidth	(MHz)	216	
Channel Symbol Rate	(Msps)	180	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.83	
Channel Throughput	(Mbps)	296.15	
Uplink		**Forward**	
E/S Carrier Frequencies	(MHz)	28963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4	
E/S Tx Antenna Gain (7.3m)	(dB)	65.60	
E/S Tx EIRP Per Channel	(dBW)	81.40	
E/S Tx RF Link Availability	(%)	99.856%	
E/S Tx Spreading Loss	(dB)	-151.13	
Satellite		**Forward**	
SV Rx G/T	(dB/K)	5.54	
SV Tx OBO	(dB)	-3.80	
SV Tx EIRP Per Channel/Carrier	dBW	45.45	
Downlink		**Forward**	
E/S Rx Carrier Frequency	(MHz)	19163	
E/S Rx Rf Link Availability	(%)	Clear	
E/S Rx Antenna Gain (2.4m)	(dBi)	51.65	
E/S Rx Effective G/T	(dB/K)	26.49	
Total Link		**Forward**	
Carrier/Noise Bandwidth	(dB)	51.93	
Carrier/Noise Uplink	(dB)	11.86	
Carrier/Noise Downlink	(dB)	19.48	
Carrier/Intermodulation Im (C/Im)	(dB)	30.00	
(C/N)- Total Actual (Es/No)	(dB)	10.58	
(C/N)-Total Required	(dB)	6.33	
(Eb/No)-Total Actual	(dB)	10.08	
(Eb/No)-Total Required	(dB)	10.08	
Excess Margin	(dB)	**4.24**	
Fade Margin	(dB)	**12.83**	

Link Budget: Forward (2)

O3b Networks Link Analysis - Tier2 Service for Melbourne Beach/U.S.A.			
ECM Link Budget Rpt - 11/19/2014		**Tier2**	**Tier2**
Parameters	Unit	**Clear Sky**	
Ground parameters		**Teleport**	**Telco**
Location		Vernon/U.S.A.	Melbourne Beach/U.S.A.
Latitude	(deg)	34.16	28.09
Longitude (East)	(deg)	260.71	279.39
E/S Range to SV	(km)	10166.69	9311.20
E/S Elevation to SV	(deg)	29.99	43.30
E/S Altitude	(km)	0.00	0.00
SV Beam Identifier	(#)	15	
Telco Offset to Beam Center	(km)	0.27	
Modulation Parameters		**Forward**	
Enter Reciever	Type	MEOLink	
Percentage of Bandwidth	(%)	100%	
Allocated Bandwidth	(MHz)	216	
Channel Symbol Rate	(Msps)	180	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.66	
Channel Throughput	(Mbps)	473.49	
Uplink		**Forward**	
E/S Carrier Frequencies	(MHz)	28963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-10	
E/S Tx Antenna Gain (7.3m)	(dB)	65.60	
E/S Tx EIRP Per Channel	(dBW)	75.40	
E/S Tx RF Link Availability	(%)	Clear	
E/S Tx Spreading Loss	(dB)	-151.13	
Satellite		**Forward**	
SV Rx G/T	(dB/K)	5.54	
SV Tx OBO	(dB)	-3.80	
SV Tx EIRP Per Channel/Carrier	dBW	45.45	
Downlink		**Forward**	
E/S Rx Carrier Frequency	(MHz)	19163	
E/S Rx Rf Link Availability	(%)	Clear	
E/S Rx Antenna Gain (2.4m)	(dBi)	51.65	
E/S Rx Effective G/T	(dB/K)	26.49	
Total Link		**Forward**	
Carrier/Noise Bandwidth	(dB)	51.93	
Carrier/Noise Uplink	(dB)	23.74	
Carrier/Noise Downlink	(dB)	19.48	
Carrier/Intermodulation Im (C/Im)	(dB)	25.00	
(C/N)- Total Actual (Es/No)	(dB)	16.56	
(C/N)-Total Required	(dB)	11.01	
(Eb/No)-Total Actual	(dB)	14.19	
(Eb/No)-Total Required	(dB)	14.19	
Excess Margin	(dB)	**5.55**	
Fade Margin	(dB)	**18.81**	

Annex 3 – Radiation Hazard Study

Radiation Hazard Study

ST5000-2.4m

This study analyzes the potential Radio Frequency (RF) human exposure levels caused by the Electro Magnetic (EM) fields of the above-captioned antenna. The mathematical analysis performed below complies with the methods described in the Federal Communications Commission Office of Engineering and Technology Bulletin No. 65 (1985 rev. 1997) R&O 96-326.

Maximum Permisible Exposure

There are two separate levels of exposure limits. The first applies to persons in the general population who are in an uncontrolled environment. The second applies to trained personnel in a controlled environment. According to 47 C.F.R. § 1.1310, the Maximum Permissible Exposure (MPE) limits for frequencies above 1.5 GHz are as follows:

- General Population / Uncontrolled Exposure 1.0 mW/cm2
- Occupational / Controlled Exposure 5.0 mW/cm2

The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the feed and the antenna surface
5. The main reflector region
6. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

Parameter	Value	Unit	Symbol
Atenna Diameter:	2.4	m	D
Antenna Transmit Gain:	54.67	dBi	G
Trasmit Frequency:	28360	MHz	f
Feed Flange Diameter:	6.00	cm	d
Power Input to the Antenna:	40.00	W	P

Calculated Parameters

The following values were calculated using the above input parameters and the corresponding formulas.

Parameter	Value	Unit	Symbol	Formula
Anenna Surface Area:	4.52	m^2	A	$\pi D^2/4$
Area of Feed Flange:	28.27	cm^2	a	$\pi d^2/4$
Antenna Efficiency:	0.58		η	$G\lambda^2/(\pi^2 D^2)$
Gain Factor:	293001.00		g	$10^{G/10}$
Wavelength:	0.0106	m	λ	$300/f$

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also are the region between the antenna main reflector and the subreflector, the region of the main reflector area and the region between the main reflector and ground.

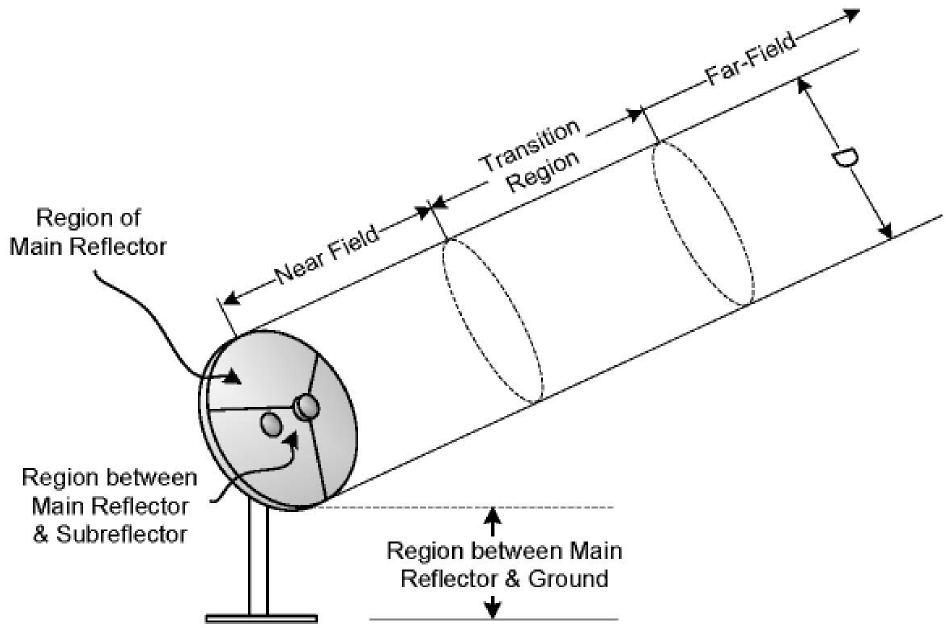


Figure 1. EM Fields as a Function of Distance

For parabolic aperture antennas with circular cross sections, such as the antenna under study, the near-field, far-field and transition region distances are calculated as follows:

Parameter	Value	Unit	Formula
Near Field Distance:	136.128	m	$R_{nf} = D^2/(4\lambda)$
Distance to Far Field:	326.707	m	Rff = 0.60D2/(λ)
Distance of Trasition Region	136.128	m	Rt = Rnf

The distance in the transition region is between the near and far fields. Thus, Rnf ≤ Rt ≤ Rff . However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, D, equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions.

Parameter	Value	Unit	Symbol	Formula
Power Density in the Near-Field	2.040	mW/cm^2	S_{nf}	$16.0\ \eta\ P/(\pi D^2)$
Power Density in the Far-Field	0.874	mW/cm^2	S_{ff}	$GP/(4\pi R_{ff}^2)$
Power Density in the Trans. Region	2.040	mW/cm^2	S_t	$S_{nf} R_{nf} /(R_t)$

The region between the main reflector and the subreflector is confined within a conical shape defined by the feed assembly. The most common feed assemblies are waveguide flanges. This energy is determined as follows:

Parameter	Value	Unit	Symbol	Formula
Power Density at the Feed Flange	5658.8	mW/cm^2	S_{fa}	$4P\ /\ a$

The power density in the main reflector is determined similarly to the power density at the feed flange; except that the area of the reflector is used.

Parameter	Value	Unit	Symbol	Formula
Power Density at Main Reflector	3.537	mW/cm^2	$S_{surface}$	$4P\ /\ A$

The power density between the reflector and ground, assuming uniform illumination of the reflector surface, is calculated as follows:

Parameter	Value	Unit	Symbol	Formula
Power Density between Reflector and Ground	0.884	mW/cm^2	S_g	$P\ /\ A$

Table 1 summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are shown below. These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

Power Densities	**mW/cm2**	**Controlled Environment (5 mW/cm2)**
Far Field Calculation	0.874	Satisfies FCC Requirements
Near Field Calculation	2.040	Satisfies FCC Requirements
Transition Region	2.040	Satisfies FCC Requirements
Region between Main and Subreflector	5658.8	Exceeds Limitations
Main Reflector Region	3.537	Satisfies FCC Requirements
Region between Main Reflector and Ground	0.884	Satisfies FCC Requirements

Table 1. Power Flux Density for Each Region

In conclusion, the results show that the antenna, in a controlled environment, and under the proper mitigation procedures, meets the guidelines specified in 47 C.F.R. § 1.1310.

Annex 4 – SpaceTrack 4000 Product Brochure

SpaceTrack 4000

Reliability Never Reached So Far™

Designed to meet the communications requirements of at-sea operations, Harris CapRock's SpaceTrack 4000 stabilized antennas are specifically engineered for offshore platforms, FPSOs, semisubmersibles and survey and seismic vessels. The SpaceTrack 4000 range of antennas support both C and Ku-band coverage, delivering the most reliable communications for global operations.

BENEFITS

- Guaranteed pointing accuracy
- Secure and reliable transmission
- Cost-efficient, high-performance networks

Certifications and Approvals

CE certified

Brazil Anatel certified

Compliant with MIL-STD 167-1A

Compliant with FCC 25.221 and FCC 25.222

Compliant with ITU and ETSI ESV specifications

Approved by Intelsat

Meets Eutelsat standards

Meets MIL-STD901 and MIL-STD461 standards

FEATURES

- Automatic satellite acquisition
- Quick and easy conversion between C and Ku-band footprints
- Supports standard GPS and Compass interfaces
- Remote diagnostics and built-in tests
- Radome air conditioning optional

Advanced Satellite Technology

The satellite technology used in SpaceTrack 4000 results in the optimum pointing of the antenna. This feature ensures that the signal is maintained despite conditions at sea and the location and direction of the vessel. Once the system is deployed, the antenna automatically locks on the appropriate signal, guaranteeing continuous and reliable transmission.

SpaceTrack 4000

Reliability Never Reached So Far™

SpaceTrack 4000 technology supports all types of seagoing vessels, resolving the challenges of geography and distance.

Technical specifications

Antenna

4012K	1.2 m diameter, Ku band, symmetrical, prime focus		
	Tx 13.75–14.5 GHz	Midband gain	Tx ~43.0 dBi
	Rx 10.95–12.75 GHz	Midband gain	Rx ~41.2 dBi
		G/T (typical)	20.0 dB/k
4012C	1.2 m diameter, C band, symmetrical, prime focus		
	Tx 5850–6425 MHz	Midband gain	Tx ~35.2 dBi
	Rx 3625–4200 MHz	Midband gain	Rx ~31.7 dBi
		G/T (typical)	11.5 dB/k
4018K	1.8 m diameter, Ku band, symmetrical, prime focus		
	Tx 13.75–14.5 GHz	Midband gain	Tx ~45.5 dBi
	Rx 10.95–12.75 GHz	Midband gain	Rx ~44.2 dBi
		G/T (typical)	22.4 dB/k
4024K	2.4 m diameter, Ku band, symmetrical, prime focus		
	Tx 13.75–14.5 GHz	Midband gain	Tx ~50.1 dBi
	Rx 10.95–12.75 GHz	Midband gain	Rx ~47.7 dBi
		G/T (typical)	25.5 dB/k
4024C	2.4 m diameter, C band, symmetrical, prime focus		
	Tx 5850–6425 MHz	Midband gain	Tx~ 42.1 dBi
	Rx 3625–4200 MHz	Midband gain	Rx ~38.2 dBi
		G/T (typical)	18.5 dB/k

Pointing accuracy

For all systems	≤ 0.2° peak
Max. vessel motion roll/pitch/yaw	8°/sec

Dimensions and weights

4012K	Radome size 1.8 m (H) × 1.8 m (D)	Antenna weight 230 kg
4012C Linear feed	Radome size 1.9 m (H) × 1.9 m (D)	Antenna weight 400 kg
4012C Circular feed	Radome size 2.7 m (H) × 2.55 m (D)	Antenna weight 400 kg
4018K	Radome size 2.7 m (H) × 2.55 m (D)	Antenna weight 450 kg
4024K	Radome size 3.75 m (H) × 3.6 m (D)	Antenna weight 750 kg
4024C	Radome size 3.75 m (H) × 3.6 m (D)	Antenna weight 750 kg

Application notes

4012K	Typical data rates[†]: 9.6–512 Kbit/sec	- Suitable for small vessels with space constraints - Minimal equipment costs - Rapid deployment version: SpaceTrack FR
4012C	Typical data rates[†]: 9.6–512 Kbit/sec	- Suitable for small vessels with space constraints - C-band operation provides global service options
4018K	Typical data rates[†]: 9.6–1024 Kbit/sec	- Suitable for small- to medium-sized vessels - Higher data rate
4024K	Typical data rates[†]: 9.6–4096 Kbit/sec	- Suitable for medium to large vessels - Large antenna size supports highest potential bit rates while minimizing space segment costs
4024C	Typical data rates[†]: 9.6–4096 Kbit/sec	- Suitable for medium to large vessels - C-band operation provides global service options - Linear or circular polarization options available