Thales Avionics, Inc.
Ka-band ESAA - Thales Modular Connectivity Terminal (MCT)
Experimental License Modification Request
File No. 0072-EX-CM-2017; Call Sign WI2XNE

Introduction

Thales Avionics, Inc. seeks to modify its active experimental license (File Number 0542-EX-PL-2016 granted October 10, 2016; Call Sign WI2XNE), by adding a second Modular Connectivity Terminal (MCT) Ka antenna to be tested at Thales's Irvine, CA facility. In addition, Thales seeks to modify the antenna's transmit gain and EIRP values to reflect performance improvements that have been confirmed in ongoing experimental testing at Thales's Melbourne, FL facility since October 2016 under the active license.

The antenna testing in Irvine will be static only, and will use Ka capacity on SES's AMC-15 satellite (Call Sign S2180) at orbital location 105.05° W.L. beginning April 24, 2017. When operating over AMC-15, the MCT will operate in the Ka-bands 28.438 - 28.563 GHz and 29.5 - 30.0 GHz (transmit); and 18.638 - 18.763 GHz and 19.7 – 20.2 GHz (receive). Note that during experimental testing the MCT will not transmit in the 29.1 - 29.25 GHz spectrum, to preclude any potential for interference with LMDS or NGSO operations.

The MCT to be tested in Irvine is technically identical to the unit already under test in Melbourne, FL under the active experimental license. Melbourne testing has shown slight improvements in antenna performance. Specifically, the transmit gain has increased from 38.4 dBi to 38.9 dBi (at 29.5 GHz), and the peak transmit EIRP has increased from 45.0 dBW to 45.5 dBW. These changes have been captured in the FCC Form 442 submitted with this modification request. New antenna EIRP density plots and link budgets are also provided in this narrative, to replace and add to those provided in Thales's original experimental license filing.

As in-flight entertainment (IFE) systems evolve they are more reliant on inflight connectivity (IFC). Experimental MCT testing in Irvine will allow Thales's IFC service to be co-located with and connected to Thales's IFE system that is developed in Irvine. This setup will allow thorough performance testing and verification of the IFC-based applications and services offered to airline passengers through the IFE system.

Figure 1 below shows the configuration of the MCT system on the rooftop of the Thales building at 51 Discovery in Irvine, CA 92618.

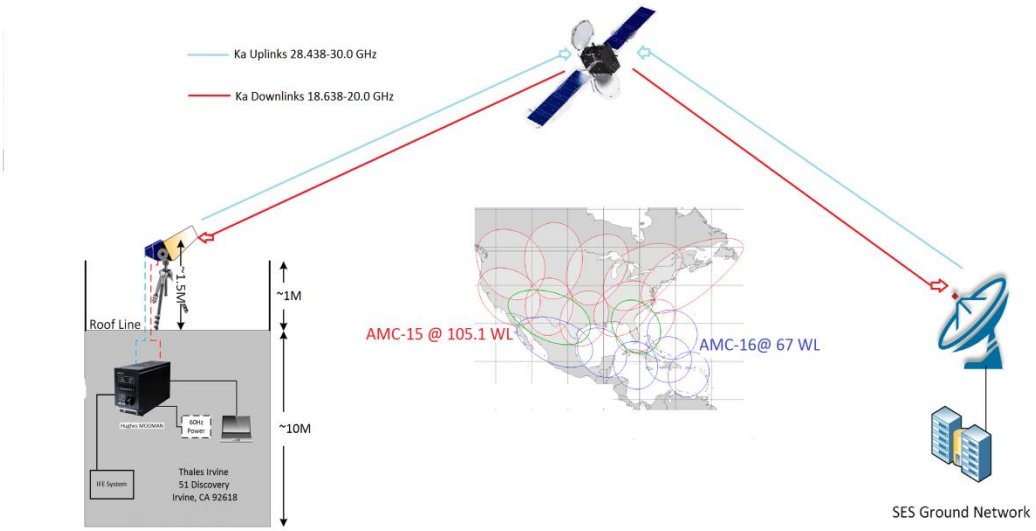


Figure 1: Static MCT Testing on Rooftop of Thales Irvine Building

Irvine's MCT testing will be conducted in close coordination with SES. Testing will be conducted intermittently between the hours of 8 AM and 6 PM Pacific Time, Monday through Friday, and occasionally on weekends.

Thales will cease transmissions as soon as possible in the case of any inadvertent, reported interference. Thales' 24/7 point of contact (POC) is:

Martin Matura
mobile: 321-292-0878
email: martin.matura@us.thalesgroup.com

The SES controlling Ka-band earth stations to be used during experimental tests are:

FCC Call Sign E160017 – Shenandoah, VA 22842
FCC Call Sign E160021 – Mt. Airy, Carroll, MD 21771

The SES Network Operations Center (NOC) in Manassas, VA 24/7 phone number is:
703-330-3305 (option #1), or 1-866-244-5012 (option #1).

Proposed Transmission Plan and Inbound Carrier Summary

The range of possible carrier modulation and coding formats (modcods) to be used during new experimental testing in Irvine and ongoing in Melbourne is shown in Table 1 below.

Modulation	FEC Rate	Spread Factor
SS-OQPSK	1/2	2
SS-OQPSK	2/3	2
SS-OQPSK	4/5	2
SS-OQPSK	9/10	2
OQPSK	1/2	1
OQPSK	2/3	1
OQPSK	4/5	1
OQPSK	9/10	1

Table 1: Range of Possible MODCODs for Inbound Carriers

Irvine Testing (new)

The new Irvine, CA static test location coordinates are 33.6°N, 117.8°W. The skew angle to AMC-15 is 18.3°, or approximately 20°.

Table 2 below provides a representative summary of the inbound carriers and parameters expected during MCT testing in Irvine. The worst-case EIRP spectral density of 45.4 dBW/MHz is 2.4 dB below the 47.8 dBW/MHz density limit shown in the 20° skew plots that follow Table 2.

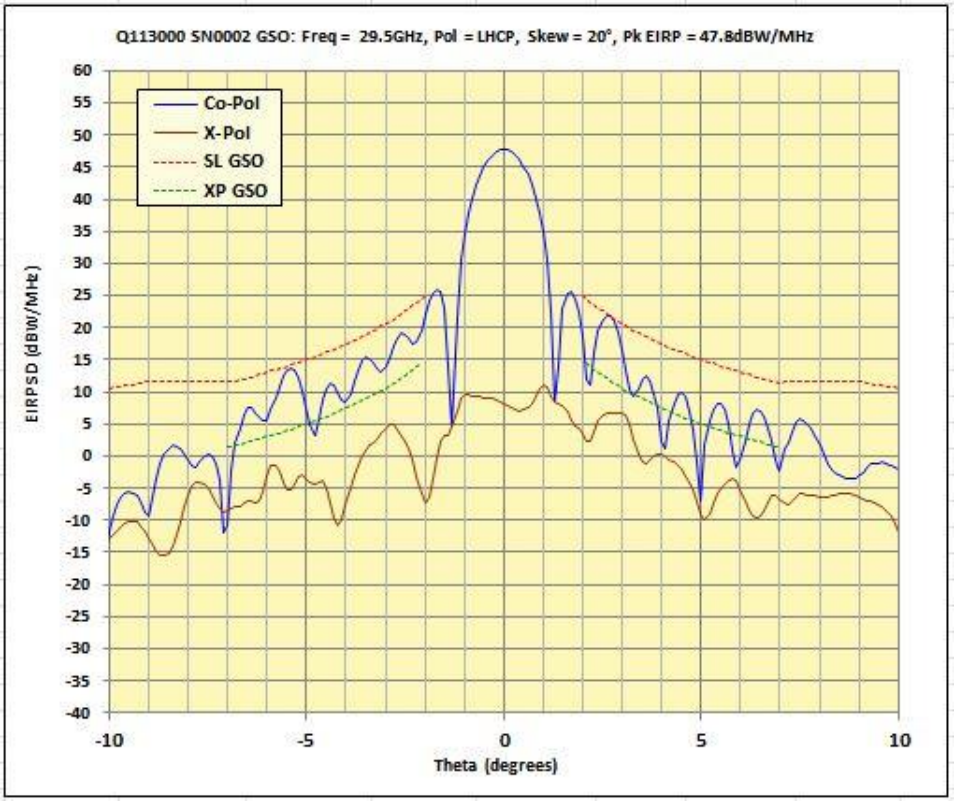
	Terminal location in AMC-15 beam 3B	Modcod	Symbol Rate (Msps)	Info Rate (Mbps)	Occupied BW (MHz)	Power SD @antenna flange (dBW/MHz)	Transmit EIRP SD (dBW/MHz)
Inbound Carrier 1	G/T=13.0 dB/K	OQPSK .8	1.0	1.6	1.28	6.5	**45.4***
Inbound Carrier 2	G/T=13.0 dB/K	OQPSK 2/3	2.0	2.7	2.56	3.5	42.4
Inbound Carrier 3	G/T=13.0 dB/K	OQPSK 1/2	4.1	4.1	5.12	0.5	39.4

*** worst-case transmit EIRP spectral density during Irvine experimental testing**

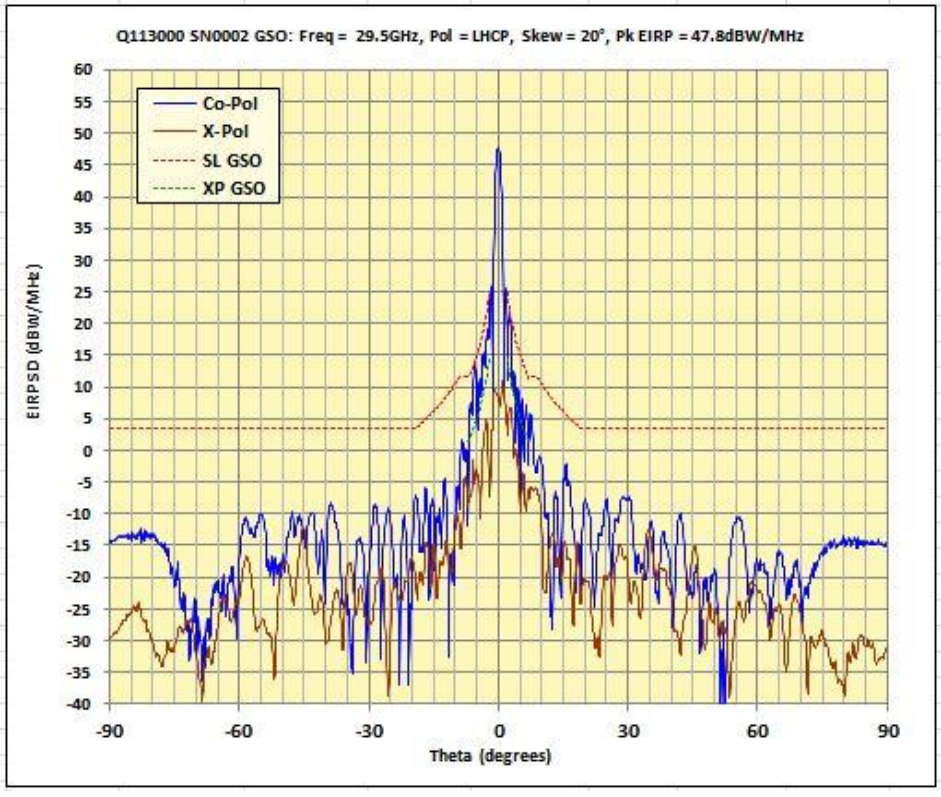
Table 2: Representative Inbound Carrier Parameters – Irvine MCT

On the following pages, measured EIRP spectral density plots are provided for a skew angle of 20°, at 29.5 GHz. The antenna performance is fully compliant with the requirements in FCC 47 CFR §25.138(a) (FCC masks shown as red dashed line).

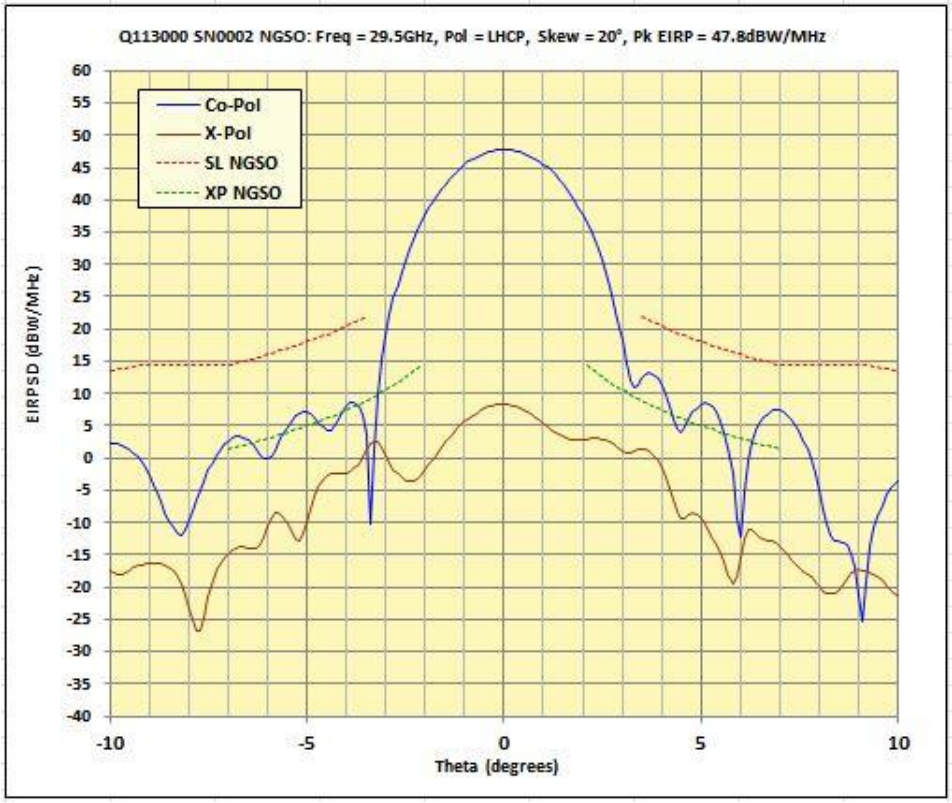
EIRP SD for 20° Skew Angle (Irvine) to AMC-15 @ 105.05° WL - GSO Plane +/-10°



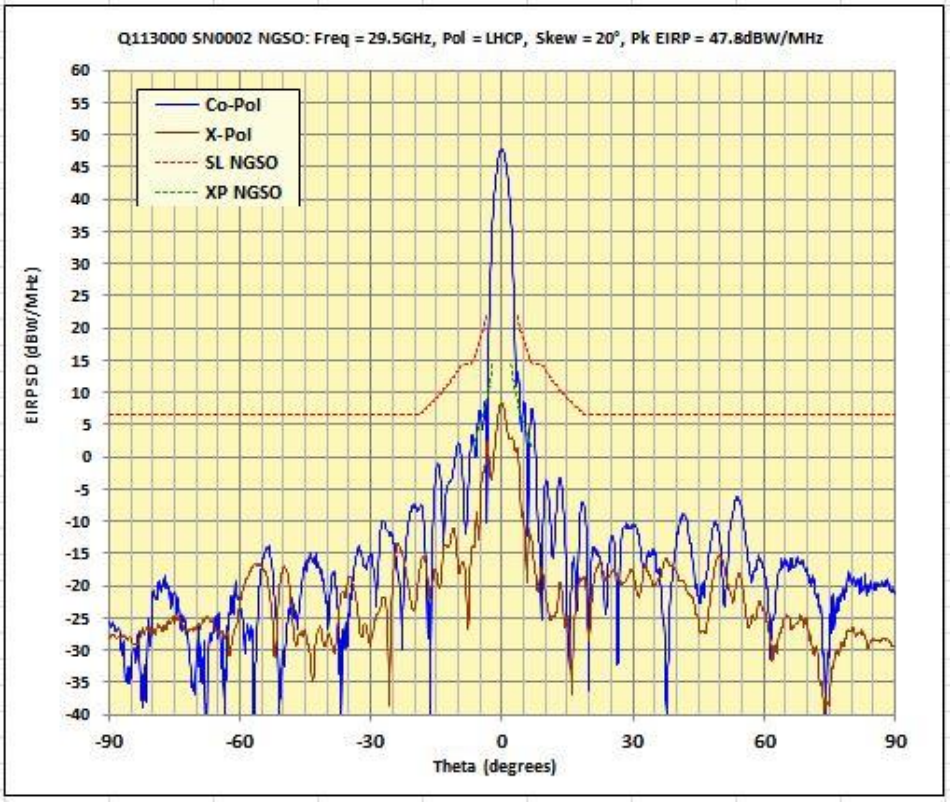
EIRP SD for 20° Skew Angle (Irvine) to AMC-15 @ 105.05° WL - GSO Plane +/-90°



EIRP SD for 20° Skew Angle (Irvine) to AMC-15 @ 105.05° WL - NGSO Plane +/-10°



EIRP SD for 20° Skew Angle (Irvine) to AMC-15 @ 105.05° WL - NGSO Plane +/-90°



A representative Irvine clear-sky link budget for the worst-case EIRP spectral density in Table 2 (45.4 dBW/MHz) is provided below.

Relevant terminal transmission parameters are:

- Antenna transmit gain (at 29.5 GHz): 38.9 dBi
- SSPB maximum output power (before losses): 16 watts
- SSPB-to-antenna flange insertion losses: 4.4 dB
- Peak transmit EIRP at antenna: 45.5 dBW

Satellite Input Parameters	Value	Units
Satellite longitude	105W	degrees
Transponder type	LTWTA	
G/T Reference	13.0	dB/K
SFD Reference	-92	dBW/m2
Receive G/T	13.0	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	-92.00	dBW/m2
Satellite ALC	0	dB
EIRP (saturation)	61.7	dBW
Transponder bandwidth	39	MHz
Input back off total	3.25	dB
Output back off total	3.25	dB
C/IM	18.00	dB
Carriers per transponder	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	4-PSK	
Required Eb/No	4.26	dB
Symbol rate	1.024	Mbaud
Information rate overhead	0	%
FEC code rate	.8	
Spreading gain	0	dB
(1 + Roll off factor)	1.25	
Carrier spacing factor	1.25	
Bandwidth allocation step size	.5	MHz
Implementation loss	0	dB
System margin	1.0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	50.85	dB/m2
Uplink C/No	98.75	dB.Hz
Downlink C/No	120.57	dB.Hz
Total C/No	98.72	dB.Hz
Uplink EIRP for saturation	70.93	dBW

General Calculations	Up	Down	Units
Elevation	48.70	36.43	degrees
True azimuth	157.71	220.26	degrees
Compass bearing	145.85	231.10	degrees
Path distance to satellite	37160.40	38062.54	km
XPD during rain	0.00	0.00	dB
Propagation time delay	0.123954	0.126963	seconds
Antenna efficiency	62.67	65.00	%
Antenna gain	38.90	64.43	dBi
Availability (average year)	N/A	N/A	%
Link downtime (average year)	N/A	N/A	hours
Availability (worst month)	N/A	N/A	%
Link downtime (worst month)	N/A	N/A	hours

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Transmit EIRP	45.54	45.54	45.54	dBW
Uplink power control used	0.00	0.00	0.00	dB
Transponder input back-off (total)	3.25	3.25	3.25	dB
Input back-off per carrier	25.39	25.39	25.39	dB
Antenna mispoint	0.20	0.20	0.20	dB
Free space loss	213.25	213.25	213.25	dB
Atmospheric absorption	0.33	0.33	0.33	dB
Tropospheric scintillation	0.00	0.00	0.00	dB
Cloud attenuation	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Total attenuation (gas-rain-cloud-scintillation)	0.33	0.33	0.33	dB
Other path losses	0.00	0.00	0.00	dB
C/No (thermal)	73.36	73.36	73.36	dB.Hz
C/N (thermal)	13.26	13.26	13.26	dB
C/ACI	27.00	27.00	27.00	dB
C/ASI	15.44	15.44	15.44	dB
C/CCI	27.00	27.00	27.00	dB
C/IM	15.00	15.00	15.00	dB
C/(N+I) [= Es/(No+Io)]	9.53	9.53	9.53	dB
Eb/(No+Io)	7.49	7.49	7.49	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	61.70	61.70	61.70	dBW
Transponder output back-off (total)	3.25	3.25	3.25	dB
Output back-off per carrier	25.39	25.39	25.39	dB
Satellite EIRP per carrier	36.31	36.31	36.31	dBW
Antenna mispoint	0.00	0.00	0.00	dB
Free space loss	209.95	209.95	209.95	dB
Atmospheric absorption	0.45	0.45	0.45	dB
Tropospheric scintillation	0.00	0.00	0.00	dB
Cloud attenuation	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Total attenuation (gas-rain-cloud-scintillation)	0.45	0.45	0.45	dB
Other path losses	0.00	0.00	0.00	dB
Noise increase due to precipitation	0.00	0.00	0.00	dB
Downlink degradation (DND)	0.00	0.00	0.00	dB
Total system noise	237.70	237.70	237.69	K
Figure of merit (G/T)	40.66	40.66	40.66	dB/K
C/No (thermal)	95.18	95.18	95.18	dB.Hz
C/N (thermal)	35.08	35.08	35.08	dB
C/ACI	27.00	27.00	27.00	dB
C/ASI	40.67	40.67	40.67	dB
C/CCI	27.00	27.00	27.00	dB
C/IM	18.00	18.00	18.00	dB
C/(N+I) [= Es/(No+Io)]	16.94	16.94	16.94	dB
Eb/(No+Io)	14.90	14.90	14.90	dB

Totals per Carrier (End-to-End)	Clear	Rain Up	Rain Dn	Units
C/No (thermal)	73.33	73.33	73.33	dB.Hz
C/N (thermal)	13.23	13.23	13.23	dB
C/ACI	23.99	23.99	23.99	dB
C/ASI	15.43	15.43	15.43	dB
C/CCI	23.99	23.99	23.99	dB
C/IM	13.24	13.24	13.24	dB
C/I (total)	10.75	10.75	10.75	dB
C/(No+Io)	68.91	68.91	68.91	dB.Hz
C/(N+I) [= Es/(No+Io)]	8.81	8.81	8.81	dB
Eb/(No+Io)	6.76	6.76	6.76	dB
Implementation loss	0.00	0.00	0.00	dB
System margin	1.00	1.00	1.00	dB
Net Eb/(No+Io)	5.76	5.76	5.76	dB
Required Eb/(No+Io)	4.26	4.26	4.26	dB
Excess margin	1.50	1.50	1.50	dB

EIRP Density Calculations	Clear	Rain Up	Rain Dn	Units
Flange transmit (up)	-53.46	-53.46	-53.46	dBW/Hz
Antenna off axis transmit toward 107W	-25.96	dBW/Hz		
Satellite (down)	-23.79	-23.79	-23.79	dBW/Hz
Flange receive (down)	-169.76	-169.76	-169.76	dBW/Hz

= 45.4 dBW/MHz

Earth Station Power Requirements	Value	Units
EIRP per carrier	45.54	dBW
Available uplink power control	0.00	dB
Total EIRP required	45.54	dBW
Antenna gain	38.90	dBi
Antenna feed flange power per carrier	6.64	dBW
HPA output back off	0.00	dB
Waveguide loss	5.4	dB
Number of HPA carriers	1	
Total HPA power required	12.0412	dBW
Required HPA power	16.0000	W

Space Segment Utilization	Value	Units
Overall availability	N/A	%
Information rate	1.6384	Mbps
Information rate (inc overhead)	1.6384	Mbps
Transmit rate	2.0480	Mbps
Symbol rate	1.0240	Mbaud
Noise Bandwidth	60.10	dB.Hz
Occupied bandwidth	1.2800	MHz
Minimum allocated bandwidth required	1.2800	MHz
Allocated transponder bandwidth	1.5000	MHz
Link efficiency	1.092	bps/Hz
Percentage transponder bandwidth used	3.85	%
Used transponder power	36.31	dBW
Percentage transponder power used	0.61	%
Max carriers / transponder	26.00	
Limited by:	Bandwidth	
Power equivalent bandwidth usage	0.2385	MHz

Melbourne Testing (Ongoing)

MCT experimental testing in Melbourne will continue over AMC-15 and AMC-16 as described in Thales's original filing narrative.

Because of the antenna performance improvements noted earlier, Table 3 below provides a new representative summary of the inbound carriers and parameters to be used during Melbourne testing over AMC-15. The worst-case EIRP spectral density of 45.4 dBW/MHz is 3.1 dB below the 48.5 dBW/MHz density limit shown in the 40° skew plots (AMC-15) following Table 3.

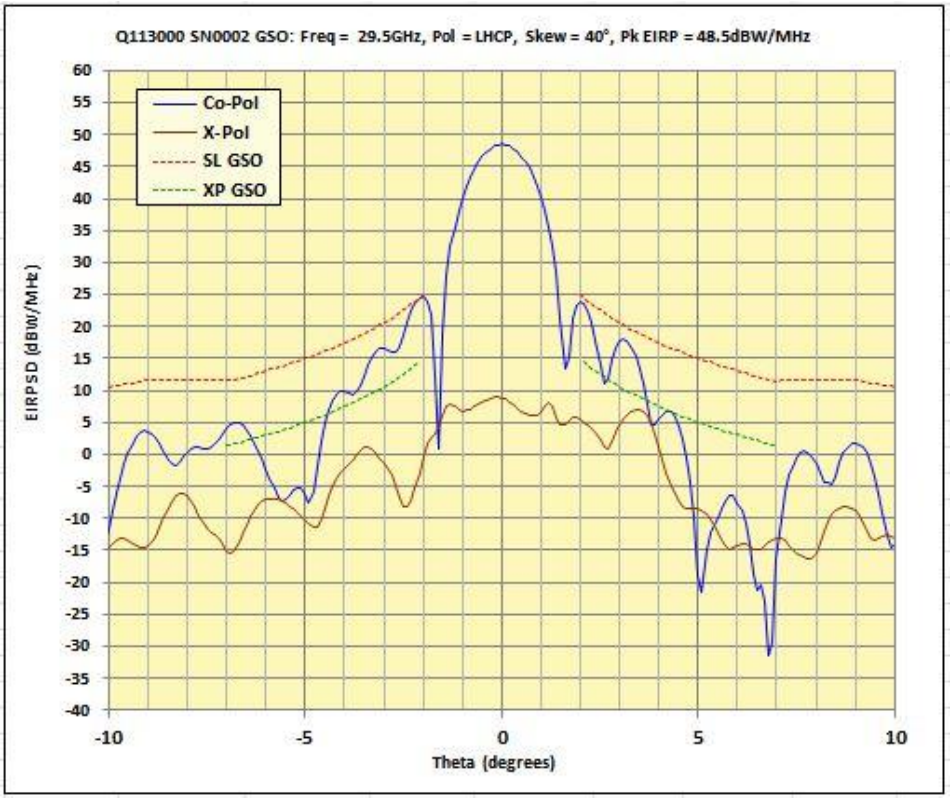
	Terminal location in AMC-15 beam 2A	Modcod	Symbol Rate (Msps)	Info Rate (Mbps)	Occupied BW (MHz)	Power SD @antenna flange (dBW/MHz)	Transmit EIRP SD (dBW/MHz)
Inbound Carrier 1	G/T=14.0 dB/K	OQPSK .8	1.0	1.6	1.28	6.5	**45.4***
Inbound Carrier 2	G/T=14.0 dB/K	OQPSK 2/3	2.0	2.7	2.56	3.5	42.4
Inbound Carrier 3	G/T=14.0 dB/K	OQPSK 1/2	4.1	4.1	5.12	0.5	39.4

*** worst-case transmit EIRP spectral density during Melbourne experimental testing**

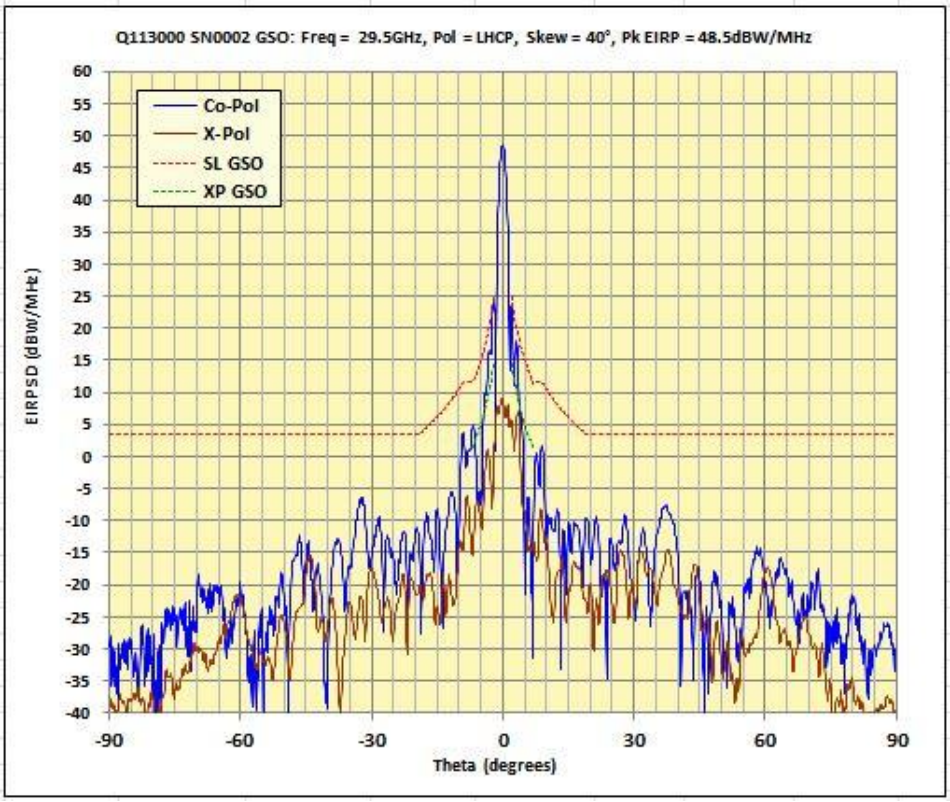
Table 3: Representative Inbound Carrier Parameters – Melbourne MCT Testing

On the following pages, measured EIRP spectral density plots are provided for skew angles of 40° and 25° at 29.5 GHz, approximating the skew angles from Melbourne to AMC-15 and AMC-16, respectively. These plots replace those provided in Thales's original experimental license filing. The antenna performance is fully compliant with the requirements in FCC 47 CFR §25.138(a) (FCC masks shown as red dashed line).

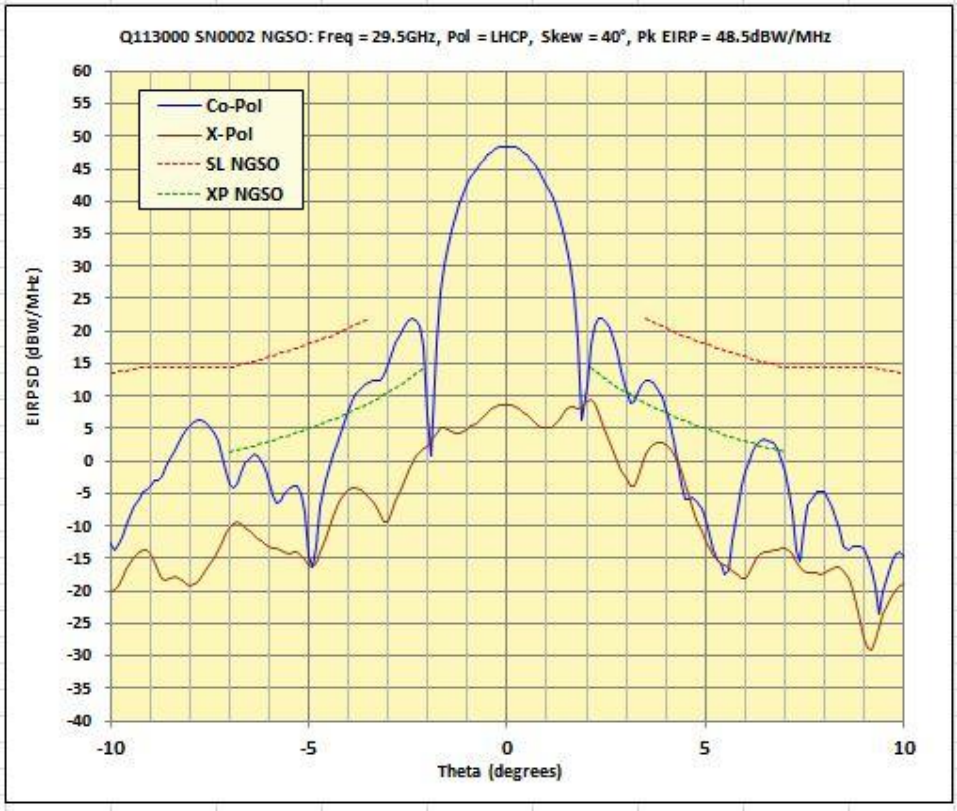
EIRP SD for 40° Skew Angle (Melbourne) to AMC-15 @ 105.05° WL - GSO Plane +/-10°



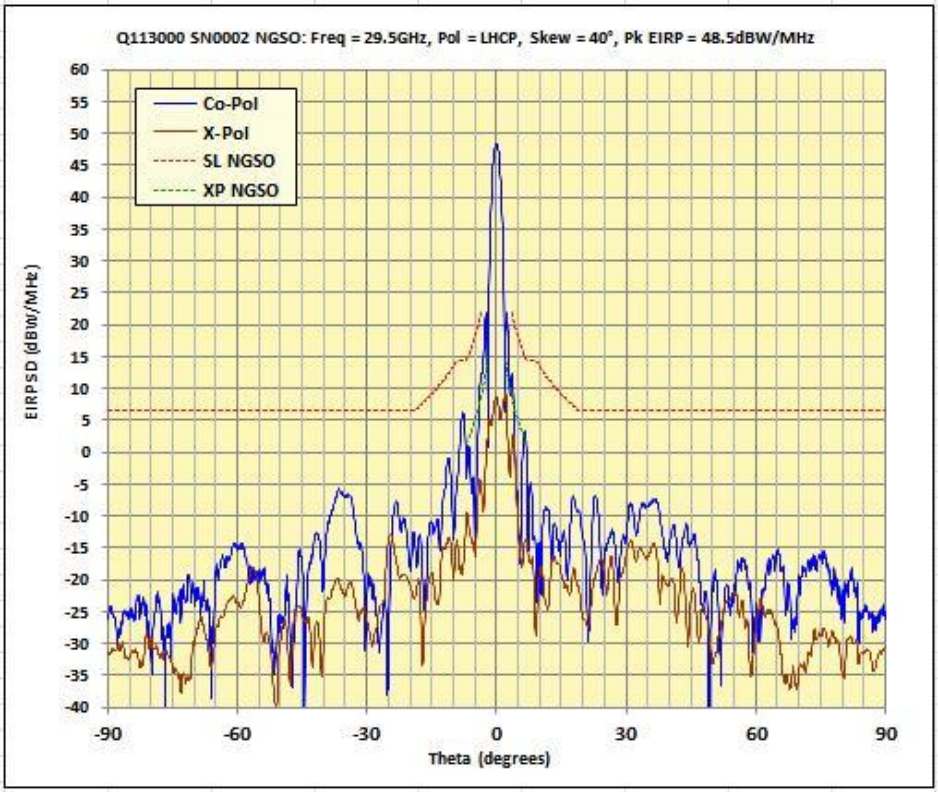
EIRP SD for 40° Skew Angle (Melbourne) to AMC-15 @ 105.05° WL - GSO Plane +/-90°



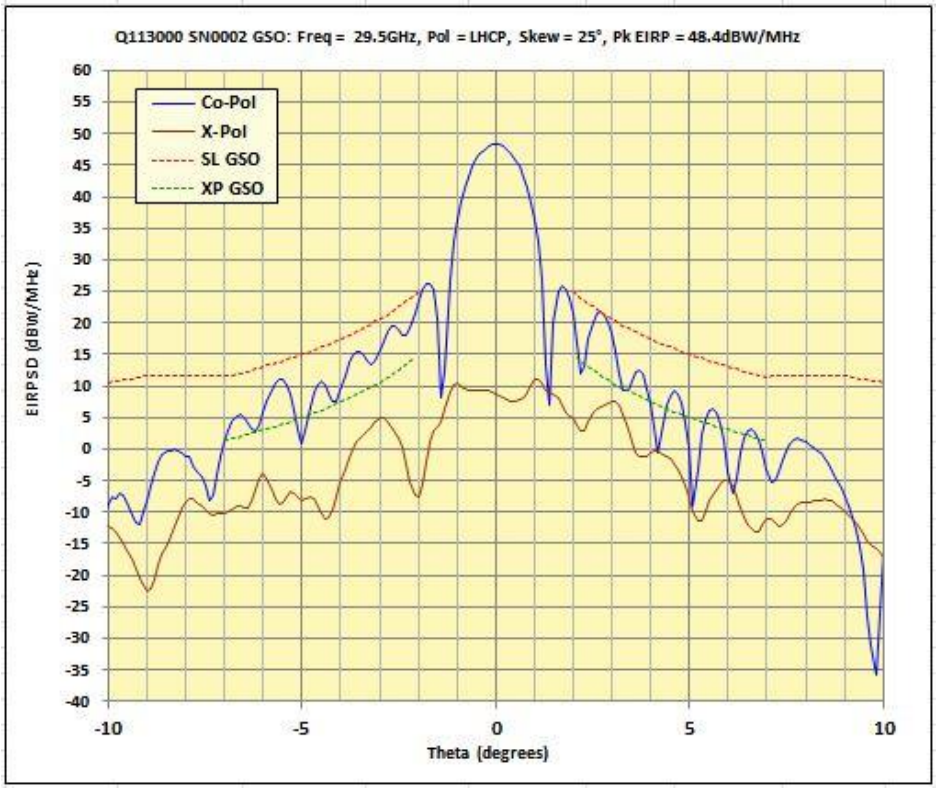
EIRP SD for 40° Skew Angle (Melbourne) to AMC-15 @ 105.05° WL - NGSO Plane +/-10°



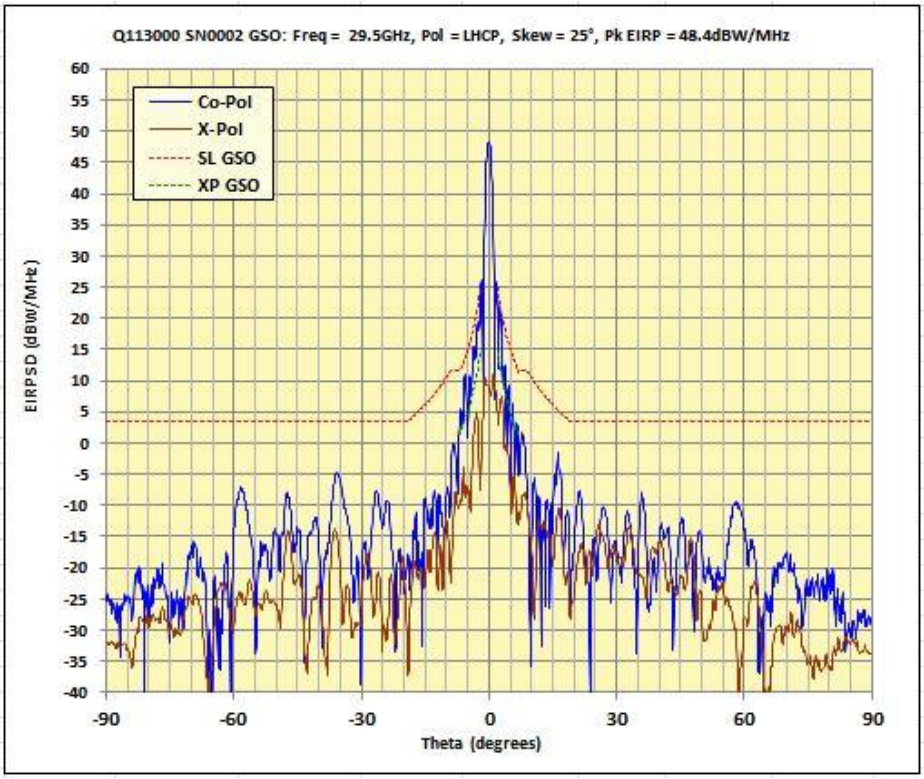
EIRP SD for 40° Skew Angle (Melbourne) to AMC-15 @ 105.05° WL - NGSO Plane +/-90°



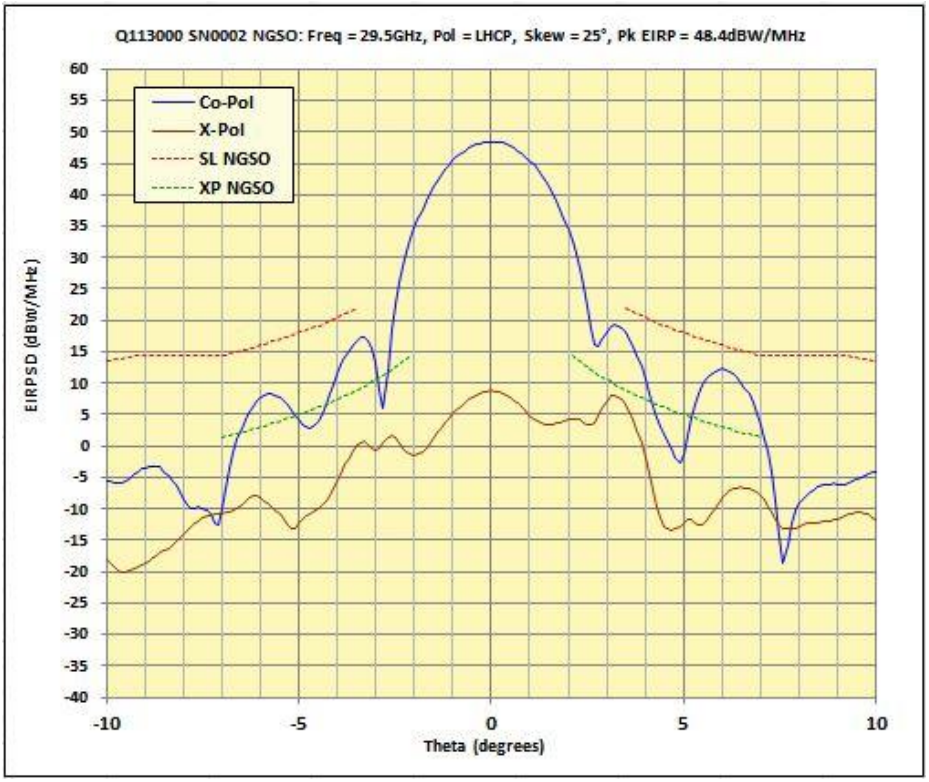
EIRP SD for 25° Skew Angle (Melbourne) to AMC-16 @ 85° WL - GSO Plane +/-10°



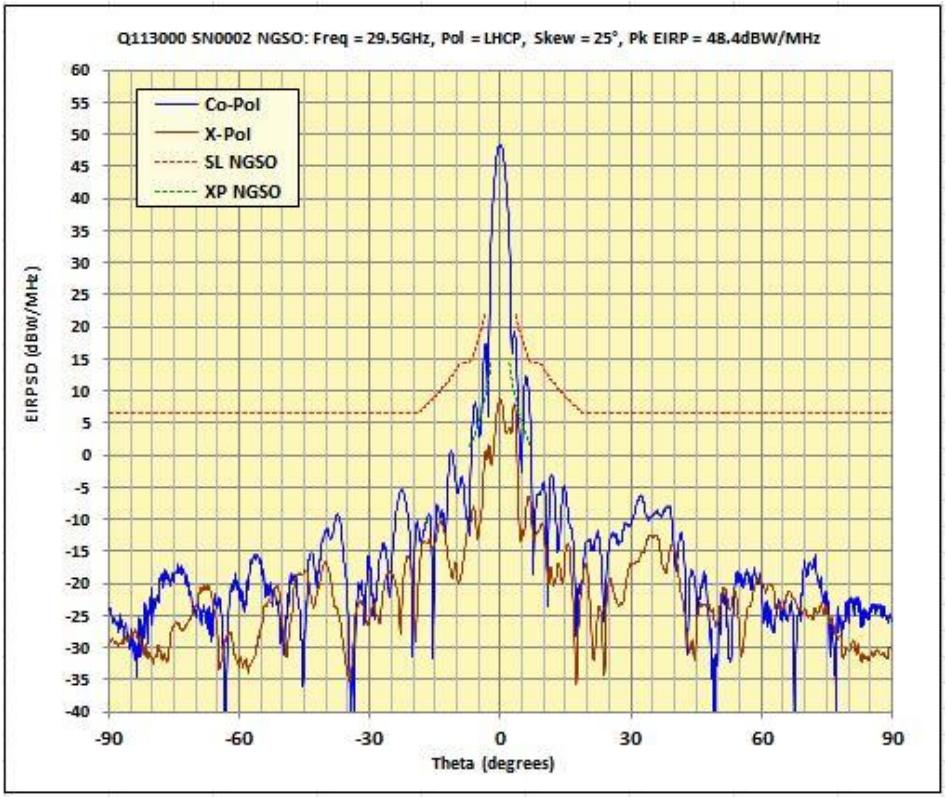
EIRP SD for 25° Skew Angle (Melbourne) to AMC-16 @ 85° WL - GSO Plane +/-90°



EIRP SD for 25° Skew Angle (Melbourne) to AMC-16 @ 85° WL - NGSO Plane +/-10°



EIRP SD for 25° Skew Angle (Melbourne) to AMC-16 @ 85° WL - NGSO Plane +/-90°



A representative Melbourne clear-sky link budget for the worst-case EIRP spectral density in Table 3 (45.4 dBW/MHz) is provided below. This replaces the link budget provided in Thales's original filing.

Relevant terminal transmission parameters are:

- Antenna transmit gain (at 29.5 GHz): 38.9 dBi
- SSPB maximum output power (before losses): 16 watts
- SSPB-to-antenna flange insertion losses: 4.4 dB
- Peak transmit EIRP at antenna: 45.5 dBW

Satellite Input Parameters	Value	Units
Satellite longitude	105W	degrees
Transponder type	LTWTA	
G/T Reference	10.5	dB/K
SFD Reference	-93	dBW/m2
Receive G/T	14.0	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	-96.50	dBW/m2
Satellite ALC	0	dB
EIRP (saturation)	61.7	dBW
Transponder bandwidth	39	MHz
Input back off total	3.25	dB
Output back off total	3.25	dB
C/IM	18.00	dB
Carriers per transponder	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	4-PSK	
Required Eb/No	4.26	dB
Symbol rate	1.024	Mbaud
Information rate overhead	0	%
FEC code rate	.8	
Spreading gain	0	dB
(1 + Roll off factor)	1.25	
Carrier spacing factor	1.25	
Bandwidth allocation step size	.5	MHz
Implementation loss	0	dB
System margin	1.0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	50.85	dB/m2
Uplink C/No	95.25	dB.Hz
Downlink C/No	120.57	dB.Hz
Total C/No	95.23	dB.Hz
Uplink EIRP for saturation	66.71	dBW

General Calculations	Up	Down	Units
Elevation	47.60	36.43	degrees
True azimuth	223.92	220.26	degrees
Compass bearing	230.65	231.10	degrees
Path distance to satellite	37232.59	38062.54	km
XPD during rain	0.00	0.00	dB
Propagation time delay	0.124194	0.126963	seconds
Antenna efficiency	62.67	65.00	%
Antenna gain	38.90	64.43	dBi
Availability (average year)	N/A	N/A	%
Link downtime (average year)	N/A	N/A	hours
Availability (worst month)	N/A	N/A	%
Link downtime (worst month)	N/A	N/A	hours

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Transmit EIRP	45.54	45.54	45.54	dBW
Uplink power control used	0.00	0.00	0.00	dB
Transponder input back-off (total)	3.25	3.25	3.25	dB
Input back-off per carrier	21.17	21.17	21.17	dB
Antenna mispoint	0.20	0.20	0.20	dB
Free space loss	213.26	213.26	213.26	dB
Atmospheric absorption	0.60	0.60	0.60	dB
Tropospheric scintillation	0.00	0.00	0.00	dB
Cloud attenuation	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Total attenuation (gas-rain-cloud-scintillation)	0.60	0.60	0.60	dB
Other path losses	0.00	0.00	0.00	dB
C/No (thermal)	74.08	74.08	74.08	dB.Hz
C/N (thermal)	13.98	13.98	13.98	dB
C/ACI	27.00	27.00	27.00	dB
C/ASI	15.44	15.44	15.44	dB
C/CCI	27.00	27.00	27.00	dB
C/IM	15.00	15.00	15.00	dB
C/(N+I) [= Es/(No+Io)]	9.82	9.82	9.82	dB
Eb/(No+Io)	7.78	7.78	7.78	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	61.70	61.70	61.70	dBW
Transponder output back-off (total)	3.25	3.25	3.25	dB
Output back-off per carrier	21.17	21.17	21.17	dB
Satellite EIRP per carrier	40.53	40.53	40.53	dBW
Antenna mispoint	0.00	0.00	0.00	dB
Free space loss	209.95	209.95	209.95	dB
Atmospheric absorption	0.45	0.45	0.45	dB
Tropospheric scintillation	0.00	0.00	0.00	dB
Cloud attenuation	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Total attenuation (gas-rain-cloud-scintillation)	0.45	0.45	0.45	dB
Other path losses	0.00	0.00	0.00	dB
Noise increase due to precipitation	0.00	0.00	0.00	dB
Downlink degradation (DND)	0.00	0.00	0.00	dB
Total system noise	237.70	237.70	237.69	K
Figure of merit (G/T)	40.66	40.66	40.66	dB/K
C/No (thermal)	99.40	99.40	99.40	dB.Hz
C/N (thermal)	39.30	39.30	39.30	dB
C/ACI	27.00	27.00	27.00	dB
C/ASI	44.89	44.89	44.89	dB
C/CCI	27.00	27.00	27.00	dB
C/IM	18.00	18.00	18.00	dB
C/(N+I) [= Es/(No+Io)]	16.99	16.99	16.99	dB
Eb/(No+Io)	14.95	14.95	14.95	dB

Totals per Carrier (End-to-End)	Clear	Rain Up	Rain Dn	Units
C/No (thermal)	74.07	74.07	74.07	dB.Hz
C/N (thermal)	13.97	13.97	13.97	dB
C/ACI	23.99	23.99	23.99	dB
C/ASI	15.43	15.43	15.43	dB
C/CCI	23.99	23.99	23.99	dB
C/IM	13.24	13.24	13.24	dB
C/I (total)	10.75	10.75	10.75	dB
C/(No+Io)	69.16	69.16	69.16	dB.Hz
C/(N+I) [= Es/(No+Io)]	9.06	9.06	9.06	dB
Eb/(No+Io)	7.02	7.02	7.02	dB
Implementation loss	0.00	0.00	0.00	dB
System margin	1.00	1.00	1.00	dB
Net Eb/(No+Io)	6.02	6.02	6.02	dB
Required Eb/(No+Io)	4.26	4.26	4.26	dB
Excess margin	1.76	1.76	1.76	dB

= 45.4 dBW/MHz

EIRP Density Calculations	Clear	Rain Up	Rain Dn	Units
Flange transmit (up)	-53.46	-53.46	-53.46	dBW/Hz
Antenna off axis transmit toward 107W	-25.81	dBW/Hz		
Satellite (down)	-19.57	-19.57	-19.57	dBW/Hz
Flange receive (down)	-165.54	-165.54	-165.54	dBW/Hz

Earth Station Power Requirements	Value	Units
EIRP per carrier	45.54	dBW
Available uplink power control	0.00	dB
Total EIRP required	45.54	dBW
Antenna gain	38.90	dBi
Antenna feed flange power per carrier	6.64	dBW
HPA output back off	0.00	dB
Waveguide loss	5.4	dB
Number of HPA carriers	1	
Total HPA power required	12.0412	dBW
Required HPA power	16.0000	W

Space Segment Utilization	Value	Units
Overall availability	N/A	%
Information rate	1.6384	Mbps
Information rate (inc overhead)	1.6384	Mbps
Transmit rate	2.0480	Mbps
Symbol rate	1.0240	Mbaud
Noise Bandwidth	60.10	dB.Hz
Occupied bandwidth	1.2800	MHz
Minimum allocated bandwidth required	1.2800	MHz
Allocated transponder bandwidth	1.5000	MHz
Link efficiency	1.092	bps/Hz
Percentage transponder bandwidth used	3.85	%
Used transponder power	40.53	dBW
Percentage transponder power used	1.62	%
Max carriers / transponder	26.00	
Limited by:	Bandwidth	
Power equivalent bandwidth usage	0.6301	MHz