Technical Brief for TECOM KaStream5000 SATCOM System

November 24, 2015

ITC Document No:
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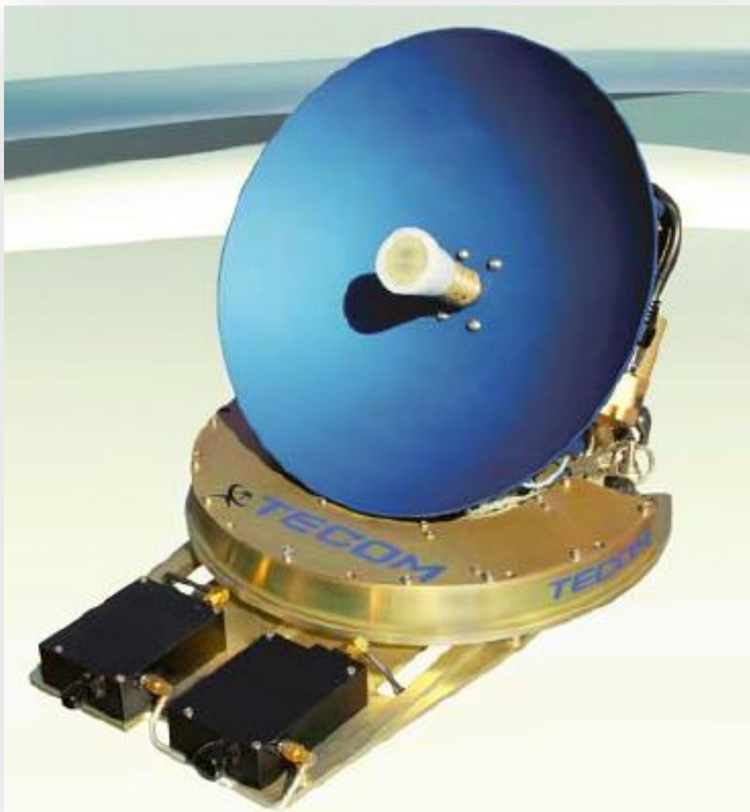

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Intellicom Technologies, Inc.

Approved by: Paul Moller Vice-President, Intellicom Technologies Inc.	

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Revision History

Revision History:	Date	Document Revision Description
V01.1	2015 11 04	Initial draft
V02.1-2.5	2015 11 08 to 2015 11 20	Release to TECOM
V03.1	2015 11 24	Release to FCC

2 INTRODUCTION

TECOM is seeking an FCC license for the operation of its KaStream5000 system with the following attributes:

- Earth Station License (vs. VSAT/blanket)
- CONUS operation

While the antenna is intended for operation on an aircraft, TECOM is currently seeking an experimental license for static ground based testing. TECOM may request an amendment for airborne and motion testing at a later date.

The terminal is filed as compliant with:

47CFR25.138 Ka Band GSO FSS Earth Stations

- Compliant with Off-axis EIRP spectral density 25.138(a)(1) within+/-3°
- Compliant with Off-axis EIRP spectral density 25.138(a)(2) other than +/-3°
- Compliant with EIRP spectral density 25.138(a)(4) cross-pol

47CFR25.227, ESAA, para (a)(1)

- The terminal is compliant with pointing and cessations requirements of 47CFR§25.227 with the 47CFR§25.138 off-axis EIRP spectral density mask applied. Note that Off-axis EIRP spectral density 25.138 shall replace section **(a)(1)(i)** of 25.227.

- **(a)(1)(ii)(A)** Each terminal transmitter shall maintain a pointing error of less than or equal to **0.2°** between the orbital location of the target satellite and the axis of the main lobe of the terminal antenna

- **(a)(1)(iii)(A)** For ESAAs operating under paragraph (a)(1)(ii)(A) of this section, all emissions from the terminal shall automatically cease within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the terminal antenna exceeds 0.5°, and transmission shall not resume until such angle is less than or equal to 0.2°"

- In addition, this filing demonstrates compliance with and provides the information set forth in paragraphs:
  - (a)(4) through (a)(16) and
  - (b)(1) and (b)(4) through (b)(8)
    - The system is not currently compliant with Data Logging (b)(7) requirements. At this time we will request an experimental license and as such operations will be limited and will be supervised.

47CFR §25.209

Due to the small size of the antenna, the terminal does not comply with 47 CFR §25.209 Antenna Performance Standards.

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Intellicom Technologies, Inc. is representing TECOM in this matter. Please contact the following for additional information, comments, or clarifications:

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Intellicom Technologies, Inc.
480-993-2220
PMoller@ITCcom.net
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3 SYSTEM DESCRIPTION

This section provides a description of the SATCOM system. Key components are identified.

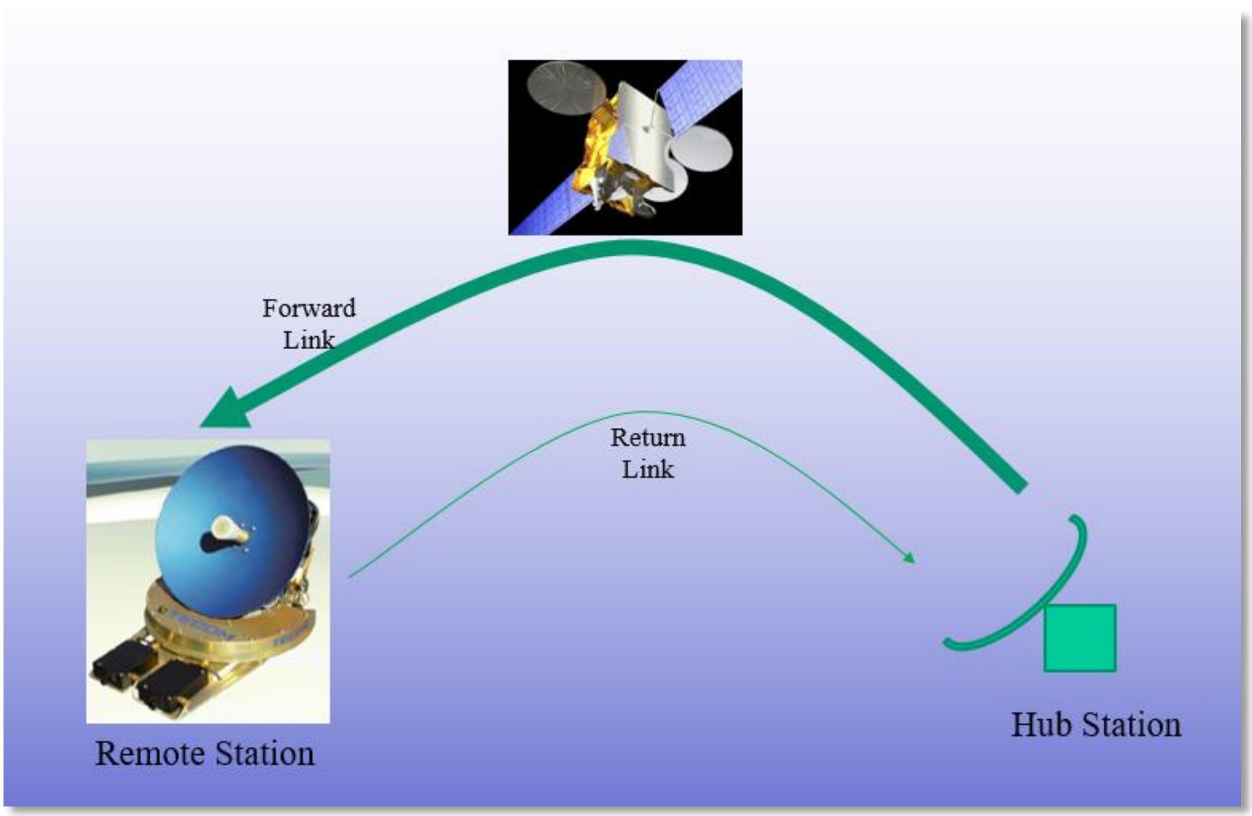
3.1 Network Configuration

TECOM is seeking an earth station terminal license. The earth station will operate in a duplex mode with a fixed hub earth station. For experimentation purposes, we request operation of 1 to 5 terminals.

Connection to private or public data services occur at the hub.

3.2 RF Transmission System

The RF transmission system includes one Hub earth station, one satellite, and one remote earth station.



3.3 Satellites (Points of Communication)

TECOM is requesting a license to operate on any of the following satellites:

- Inmarsat GX 5F2 (55W)
- Inmarsat GX 5F3(180W)
- WGS6 (135W)
- WGS1 (175E)
- WGS5 (52.5W)
- S2180 AMC-15 (105W)
- S2181 AMC-16 (85W)
- S2205 GALAXY 28 (89W)
- S2179 ECHOSTAR 9 (121W)

A link budget example is included in this document for operation using a typical satellite (Inmarsat GX at 55W) with parameters similar to the following:

Satellite Input Parameters	Value	Units
Satellite longitude	55W	degrees
Transponder type	SSPA	
Receive G/T	9	dB/K
Saturation flux density	-104	dBW/m2
Satellite attenuator pad	8	dB
Satellite ALC	0	dB
EIRP (saturation)	52	dBW
Transponder bandwidth	40	MHz
Input back off total	7.5	dB
Output back off total	3.5	dB
Intermodulation interference	16.5	dB
Number of transponder carriers	AUTO	

3.4 Master/Hub Earth Station

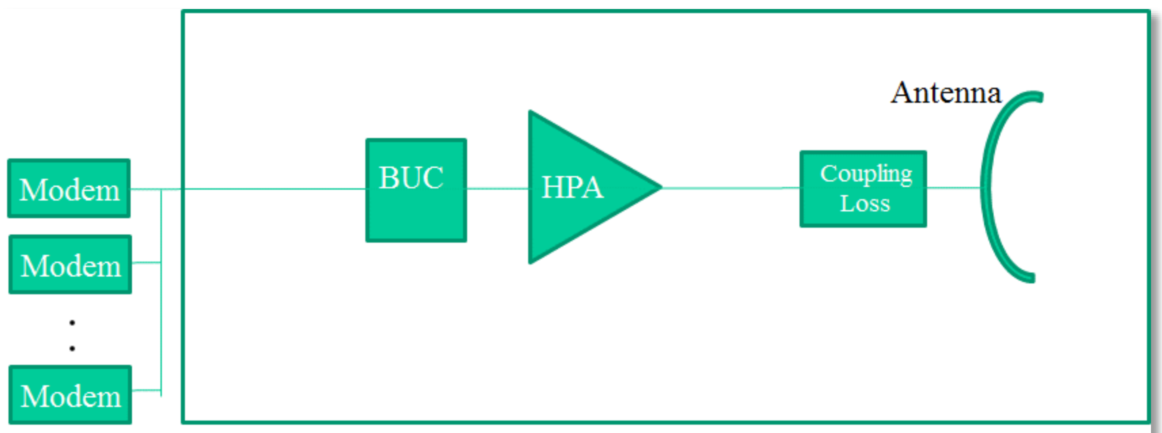
One of several fixed hub earth stations may be used for support of the experimental operations.

No hub station has been identified at this time. A possible hub earth station has the following attributes:

Location	San Diego, Ca
Coordinates	32 °54 ’3.0 "N (32.90N)
	117 °14 ’29.0 "W (117.24W)
Antenna	3.9 m diameter
Rx Gain	56.8 dBi mid band
LNA	120 K
G/T	31.3 dB/K

A hub earth station will be licensed under a separate FCC license.

- Call sign TBD
- Tx frequencies 29.0 to 31.0 GHz
- Rx Frequencies 19.2 to 21.2 GHz



3.5 KaStream 5000 Earth Station

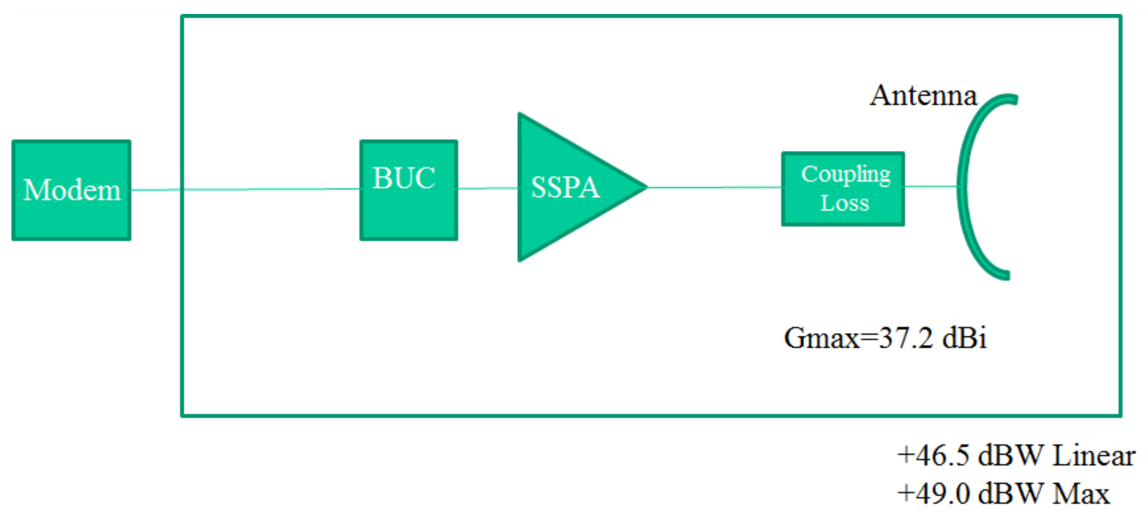
The KaStream 5000 is a Ka Band SATCOM antenna system for air transport and business aircraft terminal installations with dual civilian and military service availability. The KaStream is used to transmit and receive data to and from a geosynchronous (GEO) satellite.

The KaStream 5000 subsystem consists of:

- 12” (0.3m) diameter circular tx/rx antenna, RH/LH circular Pol feed
- Block Upconverter and SSPA (BUC)
- LNA and BDC
- Antenna Control System
    - Antenna Control Unit (ACU)
    - GPS Antenna
    - Inertial Navigation Unit (IRU) with Built-in GPS Receiver
- Modem and Manager (MODMAN)
    - Modem
    - Manager
    - 10 MHz reference

A product brochure is included in the appendix.

Following is a block diagram of the transmit portion of the terminal



Key Attributes

- Tx frequencies 29.0 to 31.0 GHz
- Rx Frequencies19.2 to 21.2 GHz
- EIRP 46.5 dBW linear, 49.0 dBW max
- Gtx = 35.5 (29 GHz) to 37.2 (30.5 GHz) dBi
- Grx = 31.07 (19.2 GHz) to 33.46 (21.2 GHz) dBi
- Feed: circular, switchable LHCP/RHCP, RX/TX
- G/T = 10.4 dB/K minimum

3.5.1 HPA/BUC Performance

Typical operation will include an output back-off necessary for meeting adjacent channel objectives or spectral regrowth (-30 dBc) characteristics defined by the satellite operator.

3.5.2 Antenna

The antenna is a 12" circular reflector antenna. The HPA and LNA are attached to the back of the antenna. Azimuth, elevation, and polarization are controlled with servo motors.

3.5.3 Pointing Performance

The antenna system is designed for aircraft dynamics but at this time will be tested static on the ground. TECOM may request an amendment for airborne and motion testing at a later date.

Note that pointing errors (static) are typically less than 0.15° (99.7% or 3 sigma).

Total pointing error analysis:

- Navigation errors (G.E. INU) <+/-0.10°
- Absolute electrical/mechanical alignment <+/-0.05°
- Pointing errors <+/-0.07° in azimuth and <+/-0.07° in elevation
- Assuming uncorrelated errors, use RSS to obtain **0.15° total pointing error**

The terminal is compliant with **47CFR25.227** antenna pointing requirements per paragraphs **(a)(1)(ii)(A)** antenna pointing requirements and the **(a)(1)(iii)(A)** cessation of emission requirements.

3.5.4 Modulation

The following table provides typical Eb/No performance for several modulation and coding combinations.

Eb/No vs. modulation and coding L3 MPM-1000		
Mod/Cod	**Eb/No (dB) for 1E-6**	**Eb/No (dB) for 1E-8**
B/QPSK R1/2 Viterbi	5.6	6.8
B/QPSK R0.435 Turbo	2.6	2.9
B/QPSK R0.5 LDPC		2.2

Modems being considered for this program include:

- L3 MPM-1000
- iDirect e8350
- Hughes HX200

Spectral spreading will be required such that FCC/ITU rules for off axis Power Spectral Density (PSD) limits will not be exceeded.

3.6 Transmit Carrier

3.6.1 ESAA Transmit

The ESAA will transmit one and only one BPSK or QPSK carrier. The actual transmission rate will depend on the customer needs, terminal maximum EIRP, link needs, and compliance with FCC 25.227 and 25.138.

The carrier attributes will be assigned and configured locally and manually. The spectrum will be used by only one transmitter at a time (N=1). No CDMA will be used.

Occupied bandwidth is 1.2 times the symbol rate.

3.7 Link Budget Summary

A sample link budget is provided in the appendix.

The link budget was used to determine the EIRP necessary to support a link from the remote to the hub for various bit rates. The transmitter is capable of providing up to 46.5 dBW EIRP (linear, regrowth -30dBc). Selection of the modulation, coding, and spreading will ensure that the EIRP density will comply with FCC 25.138.

20151104m01v01.1_kaLinkAnalysis.xlsx				
Link Required Power Required				
Link Availability	95.00%	97.00%	99.50%	
Bit Rate	500	500	500	kbps
Required Uplink EIRP	40.08	41.23	49.58	dBW

20151104m01v01.1_kaLinkAnalysis.xlsx
Assumptions
Maximum on axis EIRP spectral density = 14 dBW/40kHZ
Maximum on axis EIRP spectral density = 4 dBW/4kHZ
Turbo Code Eb/No = 2.9 dB
Satellite SFD -105 plus 8 dB attenuation
Satellite G/T = 9 dB/K
Link Location: Southern California, ground level

3.8 Antenna Patterns and Maximum EIRP Spectral Density

TECOM has thoroughly characterized the antenna transmit performance. These patterns were used to determine the maximum on axis EIRP spectral density possible while complying with the FCC 25.138 spectral density masks for azimuth, elevation, and cross pol. Below is a sample plot (see chapter 5), showing compliance with the mask with a maximum on axis EIRP spectral density of **14 dBW/40kHz**.

EIRP PSD (dBW/4kHz) vs. Angle (degrees)

TX30.5 LH

20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx

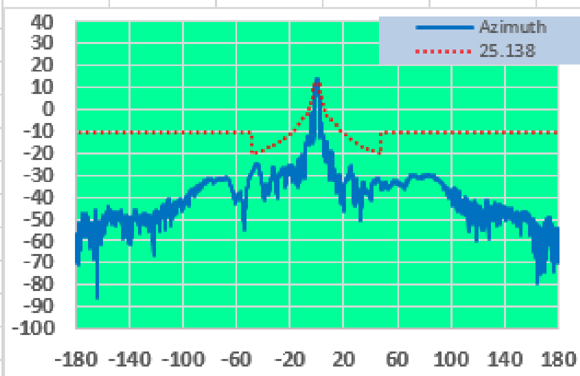
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	37.2	dBi
Max Feed Input PSD	-69	dBW/Hz

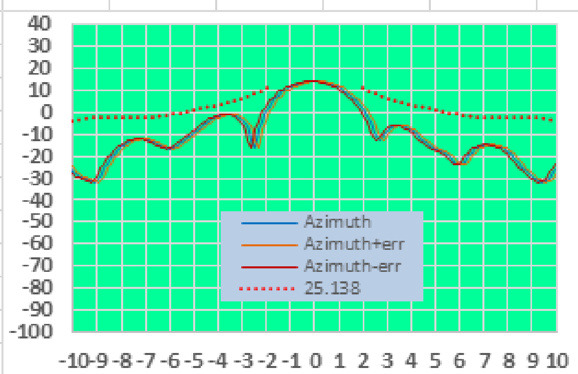
EIRP PSD (dBW/40kHz) vs. Angle (degrees)

TX30.5 LH

20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx

Azimuth





Plots show no error and with +/- pointing error

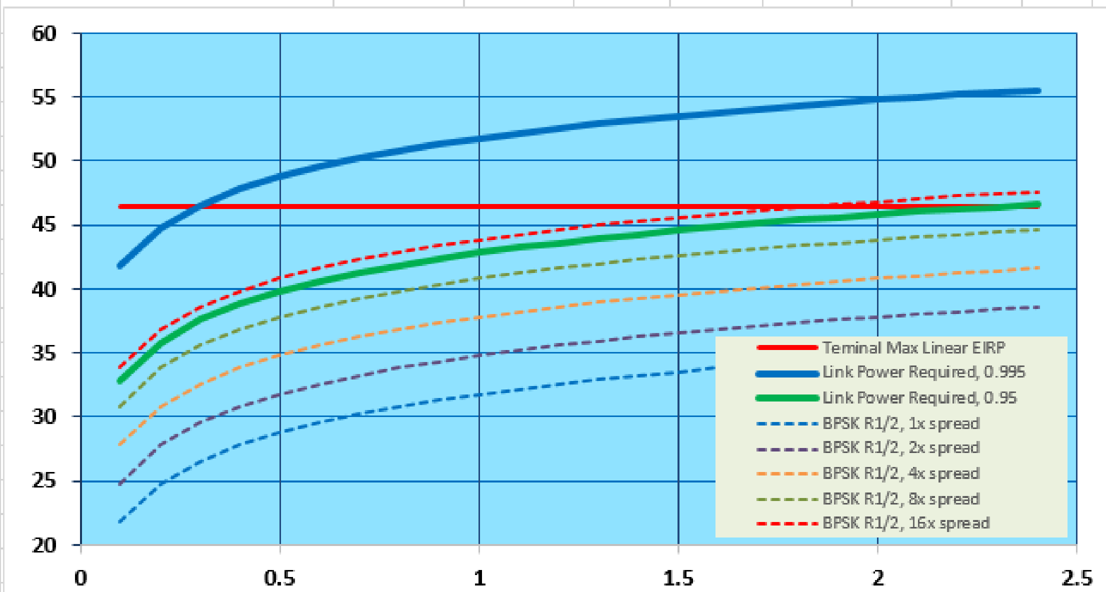
Pointing Error +/-	0.15	degrees

3.9 Spectral Density Compliance

The following charts show the EIRP needed to support a link vs. bit rate (solid Blue (99.5%) and Green (95%)). The solid red line is the maximum terminal linear EIRP. Dashed lines show the maximum EIRP density that can be transmitted while meeting FCC 25.138 vs spreading factors.

The chart demonstrates that a bit rate up to 2 Mbps is possible with 16x spreading.

EIRP (dBW) vs. Bit Rate (Mbps)
vs Spread Factor
20151104m01v01.1_kaLinkAnalysis.xlsx



20151104m01v01.1_kaLinkAnalysis.xlsx

Assumptions

Maximum on axis EIRP spectral density = 14 dBW/40kHZ
Maximum on axis EIRP spectral density = 4 dBW/4kHZ
Turbo Code Eb/No = 2.9 dB
Satellite SFD -105 plus 8 dB attenuation
Satellite G/T = 9 dB/K
Link Location: Southern California, ground level

4 FCC 25.227 Form 312

4.1 Tables

Note that Off-axis EIRP spectral density 25.138 shall replace section **(a)(1)(i)** of 25.227.

(b)(1)(A)(i) Any ESAA applicant filing an application pursuant to paragraph (a)(1) of this section shall file three tables and/or graphs depicting

- **off-axis EIRP density masks** defined by §25.227(a) and measured off-axis EIRP density levels of the proposed earth station antenna in the direction of the plane of the GSO;
- **the co-polarized EIRP density in the elevation plane**, that is, the plane perpendicular to the plane of the GSO; and
- **cross-polarized EIRP density.**

Each table shall provide the EIRP density level

- at increments of 0.1° for angles between 0° and 10° off-axis, and
- at increments of 5° for angles between 10° and 180° off-axis.

(A) For purposes of the off-axis EIRP density table in the plane of the GSO, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, and the plane of the GSO is determined by the focal point of the antenna and the line tangent to the arc of the GSO at the orbital position of the target satellite.

(B) For purposes of the off-axis co-polarized EIRP density table in the elevation plane, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, and the elevation plane is defined as the plane perpendicular to the plane of the GSO defined in paragraph (b)(1)(i)(A) of this section.

(C) For purposes of the cross-polarized EIRP density table, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite and the plane of the GSO as defined in paragraph (b)(1)(i)(A) of this section will be used.

Graphs are included in a later section. Data tables are available upon request.

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4.2 Gain and PSD Pattern

(b)(1)(A)(ii)

An ESAA applicant shall include a certification, in Schedule B, that

- the ESAA antenna conforms to the gain pattern criteria of §25.209(a) and
- (b), that, combined with the maximum input power density calculated from the EIRP density less the antenna gain, which is entered in Schedule B, demonstrates that the off-axis EIRP spectral density envelope set forth in paragraphs (a)(1)(i)(A) through (a)(1)(i)(C) of this section will be met under the assumption that the antenna is pointed at the target satellite.

47CFR §25.209
The terminal does not comply with 47 CFR §25.209.

47CFR25.138 Ka Band GSO FSS Earth Stations

- Compliant with Off-axis EIRP spectral density 25.138(a)(1) within+/-3°
- Compliant with Off-axis EIRP spectral density 25.138(a)(2) other than +/-3°
- Compliant with spectral density 25.138(a)(4) crosspol

47CFR §25.227
The terminal is compliant with the rules of 47CFR§25.227 in the plane of the geostationary arc with the **47CFR25.138** EIRP spectral density applied.

4.3 Value of N

(b)(1)(A)

The VMES applicant also shall provide the value N described in paragraph (a)(1)(i)(A) of this section.

N=1 for our system.
There will be no simultaneous use of frequency and no CDMA.

4.4 Pointing Error and Mute Provisions

(b)(1)(A)

(iii) An ESAA applicant proposing to implement a transmitter under paragraph (a)(1)(ii)(A) of this section shall:

(A) Demonstrate that the total tracking error budget of their antenna is within 0.2° or less between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna. As part of the engineering analysis, the ESAA applicant must show that the antenna pointing error is within three sigma () from the mean value, *i.e.,* that there is a 0.997 probability the antenna maintains a pointing error within 0.2°; and

(B) Demonstrate that the antenna tracking system is capable of ceasing emissions within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna exceeds 0.5°.

Pointing error data has been provided in a previous section.

TECOM declares a maximum antenna pointing error of **0.15 degrees**. A demonstration of compliance to the EIRP spectral density limits has been provided.

TECOM certifies that:

- the antenna tracking system will maintain a **pointing error of less than or equal to 0.2°** between the orbital location of the target satellite and the axis of the main lobe of the antenna and that
- the antenna tracking system is capable of ceasing emissions within **100 milliseconds** if the angle between the orbital location of the target satellite and the axis of the main lobe of the antenna **exceeds 0.5°.**

The KaStream shall enable RF transmission only when the following conditions have been met:

• Maintenance TX Inhibit Switch is Off
• no KaStream faults are detected,
• the IRU and GPS inputs to the pointing function are operating normally (no faults),
•the calculated pointing direction is not inside a 'blocked direction' mask area,
• the Polarization switch is sensed pointed to the correct polarization,
• pointing error is sensed as less than the regulatory limit
• the modem is locked on the desired satellite RX signal, and
• Transmission is enabled over Ethernet by the controller (ModMan).

The result of the MUTE logic computation shall be included in the status reported to the MODEM. Once established, transmission may be continued until the pointing error is sensed beyond the shutdown error limit. The network enforces location dependent regulatory limits via commands from the MODEM to enable or disable operations.

The geographic location determined by the IRU shall be included in the status reported to the MODEM. The MODEM enforces the requirement for continuous communications with the network control facility to enable transmissions.

4.5 Geographic Areas

(b)(4) There shall be an exhibit included with the application describing the geographic area(s) in which the ESAA will operate.

We are requesting operation within CONUS.

4.6 Contention Protocol

(b)(5) Any ESAA applicant filing for an ESAA terminal or system and planning to use a contention protocol shall include in its application a certification that will comply with the requirements of paragraph (a)(4) of this section. (a)(4) An applicant filing to operate an ESAA terminal or system and planning to use a contention protocol shall certify that its contention protocol use will be reasonable.

The Linkabit MPM-1000 modem uses a contention protocol. The NCW contention channel use complies with Table-5[1] and thus should be considered “reasonable use” per the FCC guidelines.

A full analysis of this protocol was provided to the FCC and a license was granted 8/11/2011. See: L-3 Communications license, Call sign: E100099, File Number: SES-LIC-20100817-01141.

[1] **FCC 08-246 EIGHTH REPORT AND ORDER [1]**

4.7 Point of Contact

(b)(6) The point of contact referred to in paragraph (a)(5) of this section shall be included in the application.

> (a)(5) There shall be a point of contact in the United States, with phone number and address, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the ESAA.

ESAA Operations

Primary Contact:

Martin Cox
MCox@tecom-ind.com
Cell: 805.338.5159
Switchboard 805.297.0100
Tecom Industries, Incorporated
375 Conejo Ridge Ave, Thousand Oaks, CA 91361

Secondary Contact:

Dan Cordell
dcordell@tecom-ind.com
Cell: 805.338.9685
Tecom Industries, Incorporated
375 Conejo Ridge Ave, Thousand Oaks, CA 91361

4.8 Data Logging

(b)(7) Any ESAA applicant filing for an ESAA terminal or system shall include in its application a certification that will comply with the requirements of paragraphs (a)(6), (a)(9), (a)(10), and (a)(11) of this section.

> (a)(6) For each ESAA transmitter, a record of the vehicle location (i.e., latitude/longitude/altitude), transmit frequency, channel bandwidth and satellite used shall be time annotated and maintained for a period of not less than one year. Records shall be recorded at time intervals no greater than one (1) minute while the ESAA is transmitting. The ESAA operator shall make this data available, in the form of a comma delimited electronic spreadsheet, within 24 hours of a request from the Commission, NTIA, or a frequency coordinator for purposes of resolving harmful interference events. A description of the units (i.e., degrees, minutes, MHz * * *.) in which the records values are recorded will be supplied along with the records.

At this time we are requesting an experimental license. Operations will be performed under human supervision. Data logging capabilities are not available at this time but will be developed if/when a permanent license is sought.

4.9 Radio Frequency Hazard Analysis

(b)(8) All ESAA applicants shall submit a radio frequency hazard analysis determining via calculation, simulation, or field measurement whether ESAA terminals, or classes of terminals, will produce power densities that will exceed the Commission's radio frequency exposure criteria. ESAA applicants with ESAA terminals that will exceed the guidelines in §1.1310 of this chapter for radio frequency radiation exposure shall provide, with their environmental assessment, a plan for mitigation of radiation exposure to the extent required to meet those guidelines.

All ESAA licensees shall ensure installation of ESAA terminals on aircraft by qualified installers who have an understanding of the antenna's radiation environment and the measures best suited to maximize protection of the general public and persons operating the vehicle and equipment.

An ESAA terminal exhibiting radiation exposure levels exceeding 1.0 mW/cm^2 in accessible areas, such as at the exterior surface of the radome, shall have a label attached to the surface of the terminal warning about the radiation hazard and shall include thereon a diagram showing the regions around the terminal where the radiation levels could exceed 1.0 mW/cm^2.

Please see radio frequency hazard analysis report.

4.10 Frequency Coordination

NASA, NSF coordination is not required for transmission at 29-31 GHz.

Coordination with Fixed Microwave Service (27.5-29.5 GHz, CFR Part 101) licensees may be required prior to operation within the shared band 29.0-29.5 GHz.

4.11 Protection

(a) (7) In the 10.95-11.2 GHz (space-to-Earth) and 11.45-11.7 GHz (space-to-Earth) frequency bands ESAAs shall not claim protection from interference from any authorized terrestrial stations to which frequencies are either already assigned, or may be assigned in the future.

TECOM understands and accepts (a)(7) of FCC25.227 but as applied to the receive band of 19.2 to 21.2 GHz. Satellite communications (part 25) in the 19.3-19.7 GHz band is shared with: TV(part 74F), Cable TV relay (part 78) and Fixed Microwave (part 101).

4.12 Waiver Request

We seek authority to operate the proposed mobile terminals from 29.0 to 31.0 GHz (Earth to Space). We seek a waiver for the Table of Frequency Allocations[2] to operate mobile terminals in frequency bands allocated for Fixed–Satellite (Earth to Space) operation. We request that the waiver be granted for Mobile-Satellite in the all of the following US allocated bands:

- 27.5-29.5 GHz – fixed satellite
- 29.5-30.0 GHz – fixed and mobile satellite (5.525 5.526 5.527 5.529 5.543)
- 30-31 GHz - fixed and mobile satellite (G117)

We also seek authority to operate the proposed mobile terminals from 19.2 to 21.2 GHz (Space to Earth). We seek a waiver for the Table of Frequency Allocations[3] to operate mobile terminals in frequency bands allocated for Fixed–Satellite (Space to Earth) operation. We request that the waiver be granted for Mobile-Satellite in the all of the following US allocated bands:

- 18.8-19.3 GHz – fixed satellite (US139, US334)
- 19.3-19.7 GHz – fixed satellite (US334)
- 19.7-20.2 GHz – fixed and mobile satellite (US334)
- 20.2-21.2 GHz – fixed and mobile satellite (G117)

[2] 47 CFR 2.106, August 13, 2015.
[3] 47 CFR 2.106, August 13, 2015.

5 APPENDIX

5.1 Link budget

Following is a typical link budget for the KaStream 5000 12” terminal communicating via a satellite to a 3.9m Ka Hub terminal. This link budget is prepared with BPSK R1/2 modulation for calculation of the EIRP necessary to support the link. Section 3.9 of this document describes the spectral spreading factor that is needed to comply with the FCC off-axis EIRP spectral density limits.

Digital Link Budget

Intellicom Technologies (www.ITCcom.net)
Monday, November 09, 2015

Service Name	Ka 12" to 3.9m
Coverage	GX Commercial Ka
Uplink earth station	12" Terminal Beam Center
Downlink earth station	Generic 3.9m Ka Hub
Satellite name	Inmarsat GX @ 55W

Link Input Parameters	Up	Down	Units
Site latitude	32.90N	32.90N	degrees
Site longitude	117.24W	117.24W	degrees
Site altitude	0	0	km
Frequency	29.75	19.45	GHz
Polarization	Circular	Circular	
Rain model	Crane (F)	Crane (F)	(mm/h or zone)
Availability (average year)	95	95	%
Antenna aperture	0.3	3.9	metres
Antenna efficiency / gain	+37.2	67	% (+ prefix dBi)
Coupling loss	0	1	dB
Antenna tracking / mispoint error	.2	.2	dB
LNB noise figure / temp		+120	dB (+ prefix K)
Antenna noise		90	K
Adjacent carrier interference	30	40	dB
Adjacent satellite interference	30	99	dB
Cross polarization interference	30	30	dB
Uplink station HPA output back-off	0		dB
Number of carriers / HPA	1		
HPA C/IM (up)	40		dB
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	MIN		W

Satellite Input Parameters	Value	Units
Satellite longitude	55W	degrees
Transponder type	SSPA	
Receive G/T	9	dB/K
Saturation flux density	-104	dBW/m2
Satellite attenuator pad	8	dB
Satellite ALC	0	dB
EIRP (saturation)	52	dBW
Transponder bandwidth	40	MHz
Input back off total	7.5	dB
Output back off total	3.5	dB
Intermodulation interference	16.5	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-8	
Required Eb/No without FEC coding	11.97	dB
Required Eb/No with FEC coding	3.9	dB
Information rate	0.5	Mbps
Overhead	0	%
FEC code rate	.5	
Spreading gain	0	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.4	
Bandwidth allocation step size	1	MHz
System margin	0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	50.93	dB/m2
Uplink C/No	90.67	dB.Hz
Downlink C/No	100.22	dB.Hz
Total C/No	90.22	dB.Hz
Uplink EIRP for saturation	68.67	dBW

General Calculations	Up	Down	Units
Elevation	14.66	14.66	degrees
True azimuth	105.96	105.96	degrees
Compass bearing	93.34	93.34	degrees
Path distance to satellite	40099.86	40099.86	km
Propagation time delay	0.133758	0.133758	seconds
Antenna efficiency	60.00	67.00	%
Antenna gain	37.20	56.27	dBi
Availability (average year)	95	95	%
Link downtime (average year)	438.300	438.300	hours
Availability (worst month)	88.439	88.439	%
Link downtime (worst month)	84.456	84.456	hours
Spectral power density	-58.19	-34.23	dBW/Hz

Uplink Calculation	Clear	Rain	Units
Uplink transmit EIRP	39.80	39.80	dBW
Transponder input back-off (total)	7.50	7.50	dB
Input back-off per carrier	28.87	29.44	dB
Mispoint loss	0.20	0.20	dB
Free space loss	213.98	213.98	dB
Atmospheric absorption	0.87	0.87	dB
Tropospheric scintillation fading	0.55	0.55	dB
Atmospheric losses total	1.41	1.41	dB
Total path loss (excluding rain)	215.39	215.39	dB
Rain attenuation	0.00	0.58	dB
Uplink power control	0.00	0.00	dB
Uncompensated rain fade	0.00	0.58	dB
C/No (thermal)	61.81	61.23	dB.Hz
C/N (thermal)	1.02	0.44	dB
C/ACI	30.00	29.42	dB
C/ASI	30.00	29.42	dB
C/XPI	30.00	29.42	dB
C/IM	40.00	40.00	dB
Eb/(No+Io)	4.80	4.22	dB

Downlink Calculation	Clear	Rain	Units
Satellite EIRP total	52.00	52.00	dBW
Transponder output back-off (total)	3.50	3.50	dB
Output back-off per carrier	24.87	25.44	dB
Satellite EIRP per carrier	27.13	26.56	dBW
Mispoint loss	0.20	0.20	dB
Free space loss	210.29	210.29	dB
Atmospheric absorption	0.80	0.80	dB
Tropospheric scintillation fading	0.37	0.37	dB
Atmospheric losses total	1.16	1.16	dB
Total path loss (excluding rain)	211.45	211.45	dB
Rain attenuation	0.00	0.20	dB
Noise increase due to precipitation	0.00	0.17	dB
Downlink degradation (DND)	0.00	0.38	dB
Total system noise	251.13	261.18	K
Figure of merit (G/T)	31.07	30.90	dB/K
C/No (thermal)	75.35	74.40	dB.Hz
C/N (thermal)	14.56	13.61	dB
C/ACI	40.00	39.42	dB
C/ASI	99.00	98.42	dB
C/XPI	30.00	29.42	dB
C/IM	16.50	15.92	dB
Eb/(No+Io)	16.13	15.33	dB

Totals per Carrier (End-to-End)	Clear	Rain	Units
C/No (thermal)	61.62	61.03	dB.Hz
C/N (thermal)	0.83	0.23	dB
C/ACI	29.59	29.01	dB
C/ASI	30.00	29.42	dB
C/XPI	26.99	26.41	dB
C/IM	16.48	15.91	dB
C/(No+Io)	61.48	60.89	dB.Hz
C/(N+I)	0.69	0.10	dB
Eb/(No+Io)	4.49	3.90	dB
System margin	0.00	0.00	dB
Net Eb/(No+Io)	4.49	3.90	dB
Required Eb/(No+Io)	3.90	3.90	dB
Excess margin	0.59	0.00	dB

Earth Station Power Requirements	Value	Units
EIRP per carrier	39.80	dBW
Antenna gain	37.20	dBi
Antenna feed flange power per carrier	2.60	dBW
Uplink power control	0.00	dB
HPA output back off	0.00	dB
Waveguide loss	0	dB
Filter truncation loss	0	dB
Number of HPA carriers	1	
Total HPA power required	2.6026	dBW
Required HPA power capability	1.8208	W
Spectral power density	-58.19	dBW/Hz

Space Segment Utilization	Value	Units
Overall link availability	90.250	%
Information rate (inc overhead)	0.5000	Mbps
Transmit rate	1.0000	Mbps
Symbol rate	1.0000	Mbaud
Occupied bandwidth	1.2000	MHz
Noise bandwidth	60.79	dB.Hz
Minimum allocated bandwidth required	1.4000	MHz
Allocated transponder bandwidth	2.0000	MHz
Percentage transponder bandwidth used	5.00	%
Used transponder power	27.13	dBW
Percentage transponder power used	0.73	%
Max carriers by transponder bandwidth	20.00	
Max carriers by transponder power	136.98	
Max transponder carriers limited by:-	Bandwidth	[20.00]

5.2 Antenna EIRP PSD Patterns

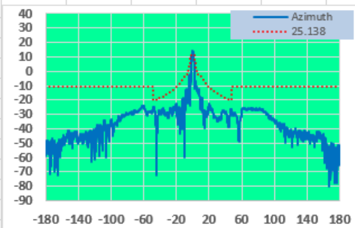
5.2.1 LHCP

5.2.1.1 LHCP 29.0 GHz

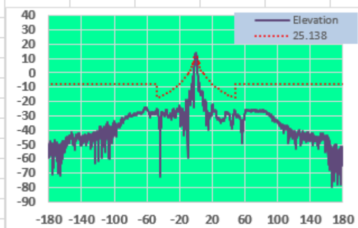
EIRP PSD (dBW/4kHz) vs. Angle (degrees)
TX29.0 LH
20151022m01v01.4_29.0.LH_AntennaPatterns.xlsx

Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	35.47	dBi
Max Feed Input PSD	-67.5	dBW/Hz

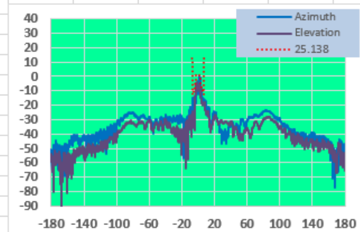
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.0 LH
20151022m01v01.4_29.0.LH_AntennaPatterns.xlsx
Azimuth

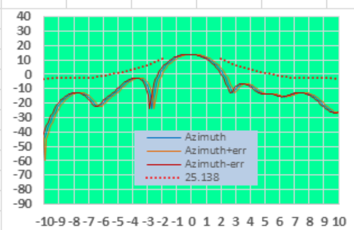


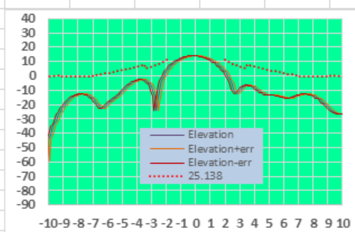
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.0 LH
20151022m01v01.4_29.0.LH_AntennaPatterns.xlsx
Elevation

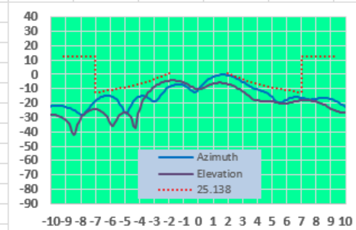


EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.0 LH
20151022m01v01.4_29.0.LH_AntennaPatterns.xlsx
XPOL









Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

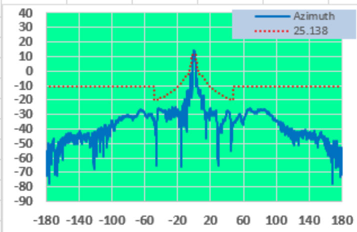
Half-Power Beamwidth		
TX29.0 LH		
20151022m01v01.4_29.0.LH_AntennaPatterns.xlsx		
Max Az	35.5	dBi
Max El	35.5	dBi
BeamWidth Az	1.2	degrees
BeamWidth El	1.2	degrees

5.2.1.2 LHCP 29.5 GHz

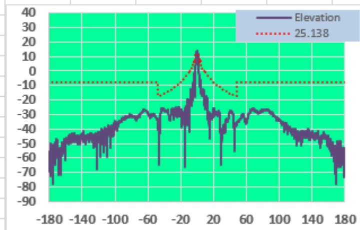
EIRP PSD (dBW/4kHz) vs. Angle (degrees)
TX29.5 LH
20151022m01v01.4_29.5.LH_AntennaPatterns.xlsx

Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	36.8	dBi
Max Feed Input PSD	-69	dBW/Hz

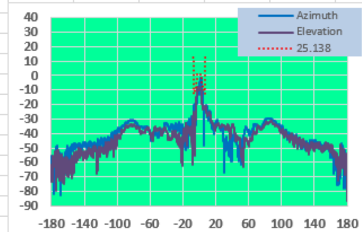
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.5 LH
20151022m01v01.4_29.5.LH_AntennaPatterns.xlsx
Azimuth

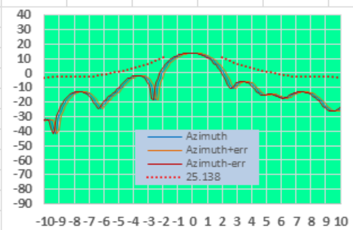


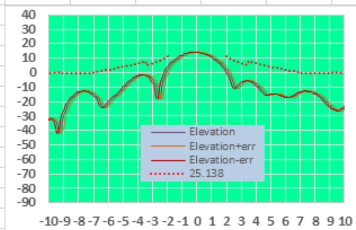
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.5 LH
20151022m01v01.4_29.5.LH_AntennaPatterns.xlsx
Elevation

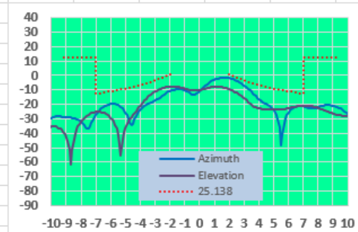


EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.5 LH
20151022m01v01.4_29.5.LH_AntennaPatterns.xlsx
XPOL









Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

Half-Power Beamwidth		
TX29.5 LH		
20151022m01v01.4_29.5.LH_AntennaPatterns.xlsx		
Max Az	36.8	dBi
Max El	36.8	dBi
BeamWidth Az	1.2	degrees
BeamWidth El	1.2	degrees

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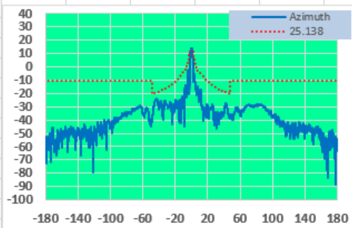
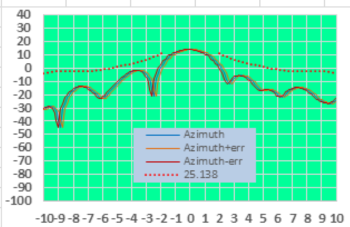
5.2.1.3 LHCP 30.0 GHz

EIRP PSD (dBW/4kHz) vs. Angle (degrees)
TX30.0 LH
20151022m01v01.4_30.0.LH_AntennaPatterns.xlsx

Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	37.0	dBi
Max Feed Input PSD	-69	dBW/Hz

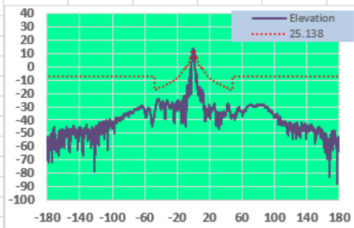
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.0 LH
20151022m01v01.4_30.0.LH_AntennaPatterns.xlsx
Azimuth

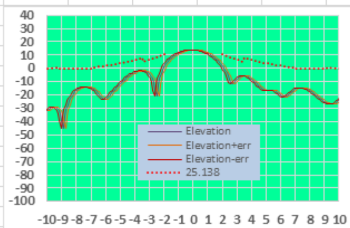




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

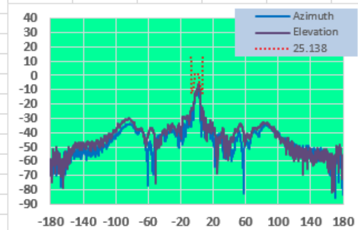
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.0 LH
20151022m01v01.4_30.0.LH_AntennaPatterns.xlsx
Elevation

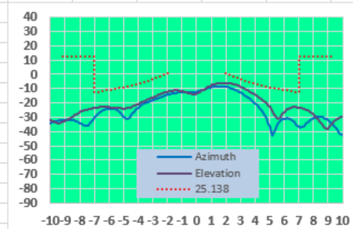




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.0 LH
20151022m01v01.4_30.0.LH_AntennaPatterns.xlsx
XPOL





Half-Power Beamwidth
TX30.0 LH
20151022m01v01.4_30.0.LH_AntennaPatterns.xlsx

Max Az	37.0	dBi
Max El	37.0	dBi
BeamWidth Az	1.1	degrees
BeamWidth El	1.1	degrees

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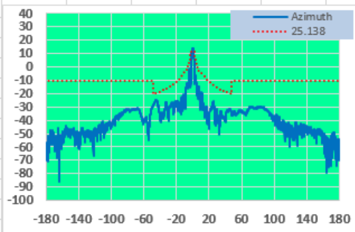
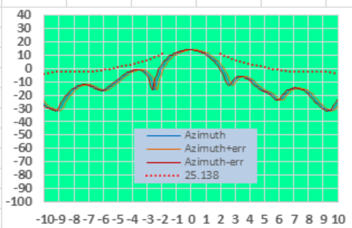
5.2.1.4 LHCP 30.5 GHz

EIRP PSD (dBW/4kHz) vs. Angle (degrees)		
TX30.5 LH		
20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx		
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	37.2	dBi
Max Feed Input PSD	-69	dBW/Hz

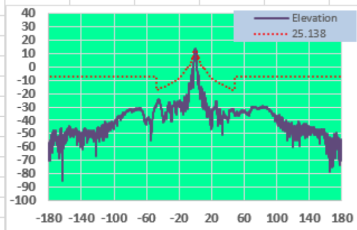
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.5 LH
20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx
Azimuth

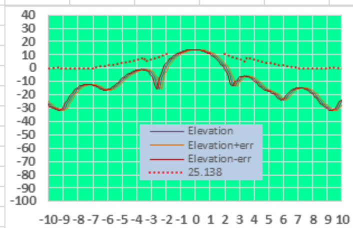




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

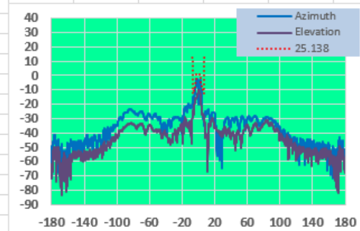
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.5 LH
20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx
Elevation

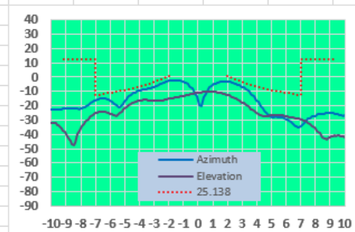




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.5 LH
20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx
XPOL



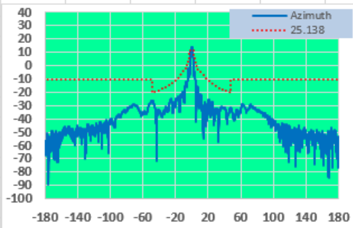


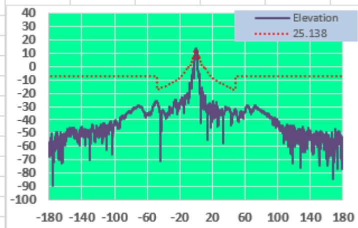
Half-Power Beamwidth		
TX30.5 LH		
20151022m01v01.4_30.5.LH_AntennaPatterns.xlsx		
Max Az	37.2	dBi
Max El	37.2	dBi
BeamWidth Az	1.1	degrees
BeamWidth El	1.1	degrees

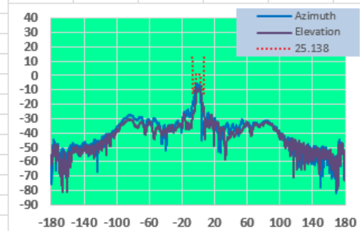
5.2.1.5 LHCP 31.0 GHz

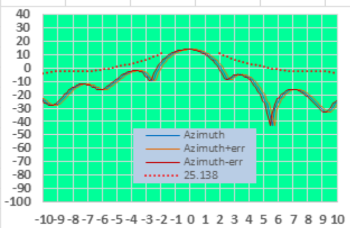
EIRP PSD (dBW/4kHz) vs. Angle (degrees)		
TX31.0 LH		
20151022m01v01.4_31.0.LH_AntennaPatterns.xlsx		
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	37.0	dBi
Max Feed Input PSD	-69	dBW/Hz

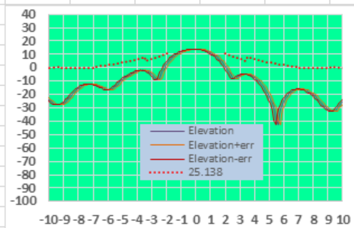
EIRP PSD (dBW/40kHz) vs. Angle (degrees)	**EIRP PSD (dBW/40kHz) vs. Angle (degrees)**	**EIRP PSD (dBW/40kHz) vs. Angle (degrees)**
TX31.0 LH	**TX31.0 LH**	**TX31.0 LH**
20151022m01v01.4_31.0.LH_AntennaPatterns.xlsx	20151022m01v01.4_31.0.LH_AntennaPatterns.xlsx	20151022m01v01.4_31.0.LH_AntennaPatterns.xlsx
Azimuth	**Elevation**	**XPOL**

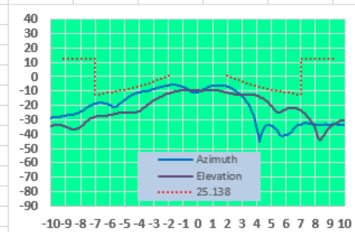












Plots show no error and with +/- pointing error			Plots show no error and with +/- pointing error		
Pointing Error +/-	0.15	degrees	Pointing Error +/-	0.15	degrees

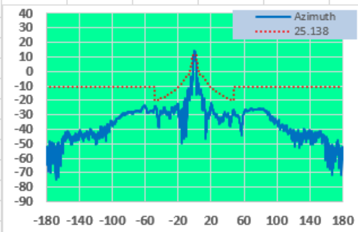
Half-Power Beamwidth		
TX31.0 LH		
20151022m01v01.4_31.0.LH_AntennaPatterns.xlsx		
Max Az	37.0	dBi
Max El	37.0	dBi
BeamWidth Az	1.2	degrees
BeamWidth El	1.2	degrees

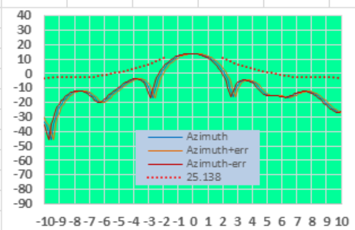
5.2.1 RHCP

5.2.1.1 RHCP 29.0 GHz

EIRP PSD (dBW/4kHz) vs. Angle (degrees)		
TX29.0 RH		
20151022m01v01.4_29.0.RH_AntennaPatterns.xlsx		
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	35.7	dBi
Max Feed Input PSD	-68	dBW/Hz

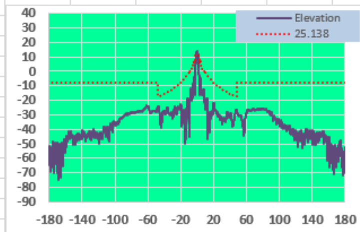
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.0 RH
20151022m01v01.4_29.0.RH_AntennaPatterns.xlsx
Azimuth

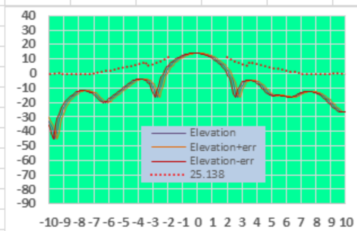




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

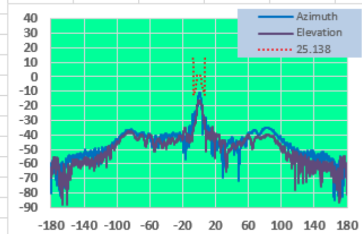
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.0 RH
20151022m01v01.4_29.0.RH_AntennaPatterns.xlsx
Elevation

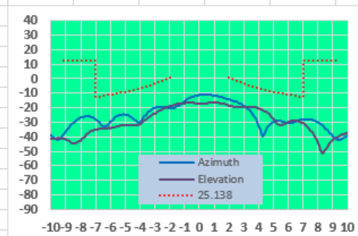




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX29.0 RH
20151022m01v01.4_29.0.RH_AntennaPatterns.xlsx
XPOL





Half-Power Beamwidth		
TX29.0 RH		
20151022m01v01.4_29.0.RH_AntennaPatterns.xlsx		
Max Az	35.7	dBi
Max El	35.7	dBi
BeamWidth Az	1.2	degrees
BeamWidth El	1.2	degrees

5.2.1.2 RHCP 29.5 GHz

EIRP PSD (dBW/4kHz) vs. Angle (degrees)

TX29.5 RH

20151022m01v01.4_29.5.RH_AntennaPatterns.xlsx

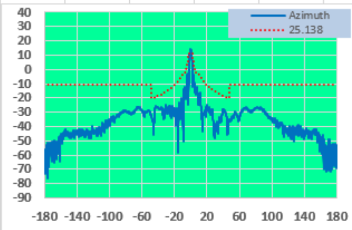
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	36.8	dBi
Max Feed Input PSD	-69	dBW/Hz

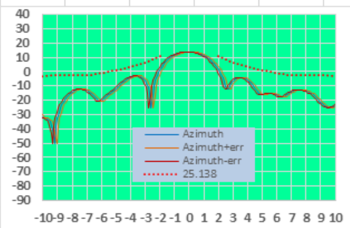
EIRP PSD (dBW/40kHz) vs. Angle (degrees)

TX29.5 RH

20151022m01v01.4_29.5.RH_AntennaPatterns.xlsx

Azimuth





Plots show no error and with +/- pointing error

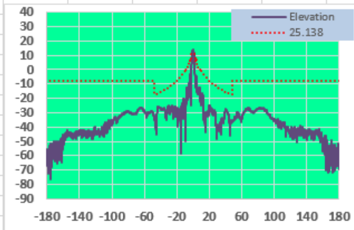
Pointing Error +/- 0.15 degrees

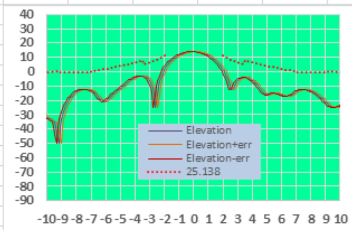
EIRP PSD (dBW/40kHz) vs. Angle (degrees)

TX29.5 RH

20151022m01v01.4_29.5.RH_AntennaPatterns.xlsx

Elevation





Plots show no error and with +/- pointing error

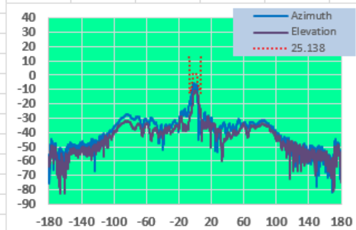
Pointing Error +/- 0.15 degrees

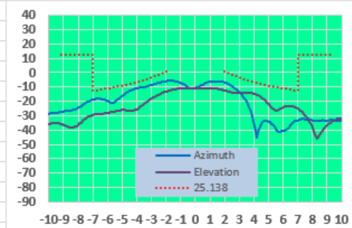
EIRP PSD (dBW/40kHz) vs. Angle (degrees)

TX29.5 RH

20151022m01v01.4_29.5.RH_AntennaPatterns.xlsx

XPOL





Half-Power Beamwidth

TX29.5 RH

20151022m01v01.4_29.5.RH_AntennaPatterns.xlsx

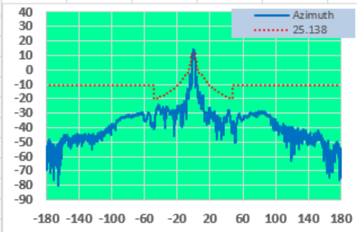
Max Az	36.8	dBi
Max El	36.8	dBi
BeamWidth Az	1.1	degrees
BeamWidth El	1.1	degrees

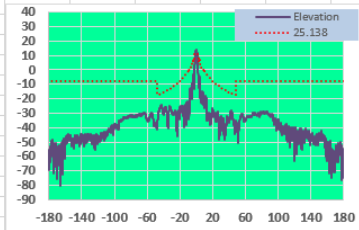
PO Box 27056, San Diego, CA 92198
Tel: (858) 486-1115, www.ITCcom.net

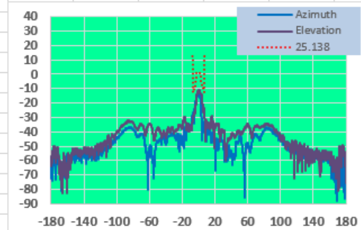
5.2.1.3 RHCP 30.0 GHz

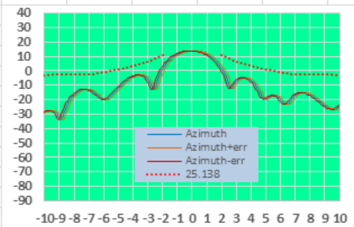
EIRP PSD (dBW/4kHz) vs. Angle (degrees)		
TX30.0 RH		
20151022m01v01.4_30.0.RH_AntennaPatterns.xlsx		
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	37.0	dBi
Max Feed Input PSD	-69	dBW/Hz

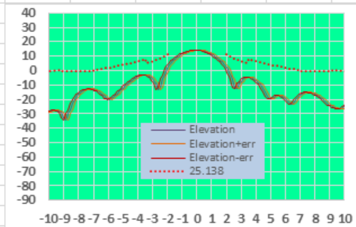
EIRP PSD (dBW/40kHz) vs. Angle (degrees)	**EIRP PSD (dBW/40kHz) vs. Angle (degrees)**	**EIRP PSD (dBW/40kHz) vs. Angle (degrees)**
TX30.0 RH	**TX30.0 RH**	**TX30.0 RH**
20151022m01v01.4_30.0.RH_AntennaPatterns.xlsx	20151022m01v01.4_30.0.RH_AntennaPatterns.xlsx	20151022m01v01.4_30.0.RH_AntennaPatterns.xlsx
Azimuth	**Elevation**	**XPOL**

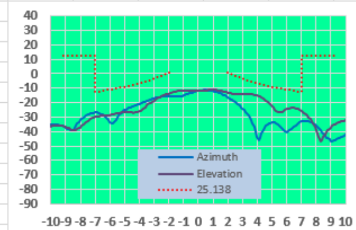












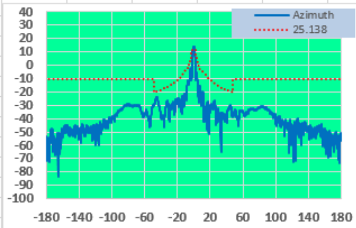
Plots show no error and with +/- pointing error			Plots show no error and with +/- pointing error		
Pointing Error +/-	0.15	degrees	Pointing Error +/-	0.15	degrees

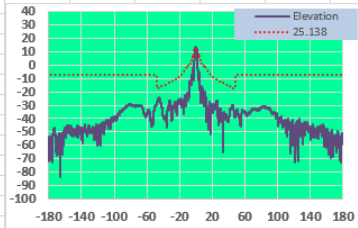
Half-Power Beamwidth		
TX30.0 RH		
20151022m01v01.4_30.0.RH_AntennaPatterns.xlsx		
Max Az	37.0	dBi
Max El	37.0	dBi
BeamWidth Az	1.1	degrees
BeamWidth El	1.1	degrees

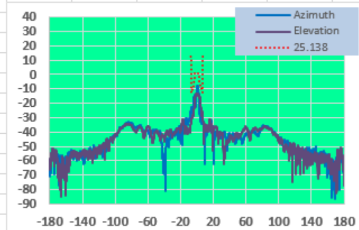
5.2.1.4 RHCP 30.5 GHz

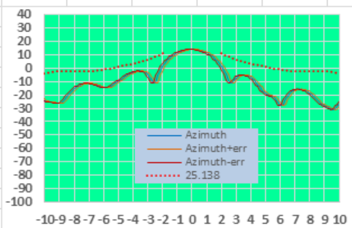
EIRP PSD (dBW/4kHz) vs. Angle (degrees)		
TX30.5 RH		
20151022m01v01.4_30.5.RH_AntennaPatterns.xlsx		
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	37.0	dBi
Max Feed Input PSD	-69	dBW/Hz

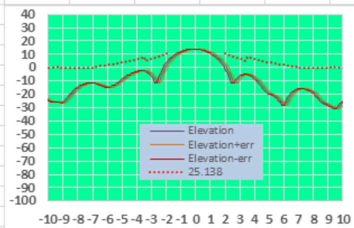
EIRP PSD (dBW/40kHz) vs. Angle (degrees)	EIRP PSD (dBW/40kHz) vs. Angle (degrees)	EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX30.5 RH	TX30.5 RH	TX30.5 RH
20151022m01v01.4_30.5.RH_AntennaPatterns.xlsx	20151022m01v01.4_30.5.RH_AntennaPatterns.xlsx	20151022m01v01.4_30.5.RH_AntennaPatterns.xlsx
Azimuth	Elevation	XPOL

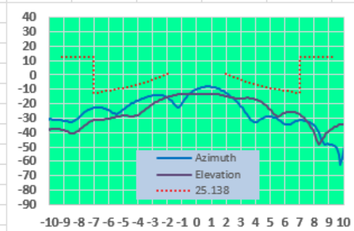












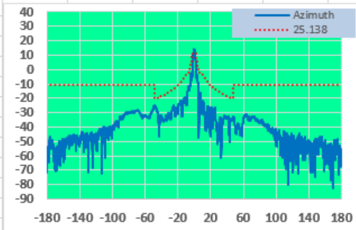
Plots show no error and with +/- pointing error			Plots show no error and with +/- pointing error		
Pointing Error +/-	0.15	degrees	Pointing Error +/-	0.15	degrees

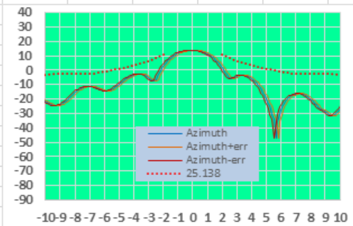
Half-Power Beamwidth		
TX30.5 RH		
20151022m01v01.4_30.5.RH_AntennaPatterns.xlsx		
Max Az	37.0	dBi
Max El	37.0	dBi
BeamWidth Az	1.1	degrees
BeamWidth El	1.1	degrees

5.2.1.5 RHCP 31.0 GHz

EIRP PSD (dBW/4kHz) vs. Angle (degrees)		
TX31.0 RH		
20151022m01v01.4_31.0.RH_AntennaPatterns.xlsx		
Max EIRP PSD	14	dBW/40kHz
Max EIRP PSD	-32	dBW/Hz
Antenna Gain	36.7	dBi
Max Feed Input PSD	-69	dBW/Hz

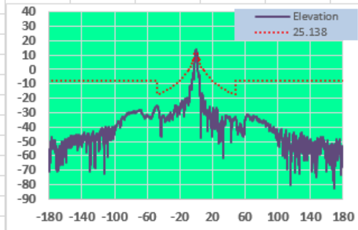
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX31.0 RH
20151022m01v01.4_31.0.RH_AntennaPatterns.xlsx
Azimuth

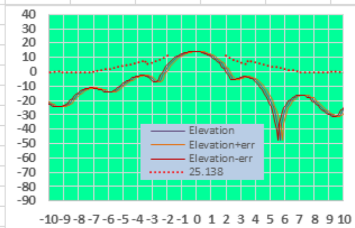




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

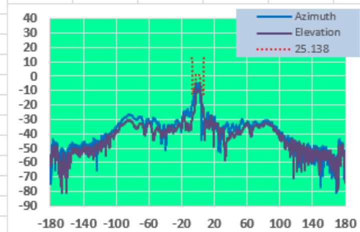
EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX31.0 RH
20151022m01v01.4_31.0.RH_AntennaPatterns.xlsx
Elevation

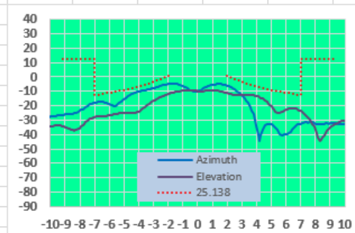




Plots show no error and with +/- pointing error
Pointing Error +/- 0.15 degrees

EIRP PSD (dBW/40kHz) vs. Angle (degrees)
TX31.0 RH
20151022m01v01.4_31.0.RH_AntennaPatterns.xlsx
XPOL





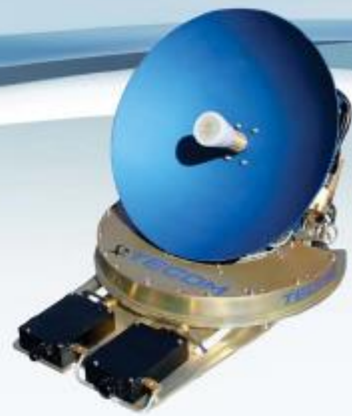
Half-Power Beamwidth		
TX31.0 RH		
20151022m01v01.4_31.0.RH_AntennaPatterns.xlsx		
Max Az	36.7	dBi
Max El	36.7	dBi
BeamWidth Az	1.2	degrees
BeamWidth El	1.2	degrees

5.3 Terminal Brochure

INNOVATIVE ANTENNA SOLUTIONS

TECOM
smiths microwave

KA/KU BAND TAILMOUNT SATCOM ANTENNA SYSTEM



- Industry leading pointing algorithm leveraging the KuStream®1000 airborne satellite connectivity solution
- Market leading EIRP utilizing highly efficient spatially combined power amplifiers
- Interchangeable Ku and Ka Band Antenna platforms (STAA only) for maximum flexibility
- Multi modem capability
- Broad frequency coverage for military and commercial use

PARAMETER	KA-BAND	KU-BAND
Operating Frequency	19.2 – 21.2 GHz RX Band 29.0 – 31.0 GHz TX Band	10.7 – 12.75 GHz RX Band 13.75 – 14.50 GHz
Polarization	Switchable LHCP/RHCP RX/TX	Linear, switchable VP/HP, TX orthogonal to RX
G/T	10.4 dB/k minimum	8.8 dB/K
EIRP	46.5 dBw Linear, 49.0 dBw PSAT	42.7 dBw
Axial Ratio	1.0 dB max TX, 1.5 dB max RX	
Azimuth Range of Motion	0 – 360 degrees Continuous Rotation	0 – 360 degrees Continuous Rotation
Elevation Range of Motion	0 – 90 degrees	0 – 90 degrees
Az/El Velocity	> 30 deg/sec	> 30 degree/sec
Az/El/Acceleration	> 30 deg/sec/sec	> 30 degree/sec/sec
Az/El Position Resolution	0.0063 degrees	0.0063 degrees
Tracking Accuracy	< 0.2 degrees RMS	< 0.2 degrees RMS
DC Power	28 VDC, 400 watts max	28 VDC, 380 watts max
Weight - ACU	13 lbs. max	
Size – ACU	Standard ARINC 600 – 4 MCU Form Factor 7.62"H x 12.675" L x 4.88" W	
Weight - STAA	26 lbs. max	26.0 lbs. max
Size – STAA	13.2" H x 16.4" L x 9.3" W Swept volume – 12.0" Diameter	16.4" L x 9.3" W at base 13.2" H x 12.0" Swept Diameter

375 Conejo Ridge Avenue, Thousand Oaks, CA 91361-4928 | Phone (805) 267-0100, Fax (805) 267-0181 | www.tecom-ind.com

5.4 Modem Brochure

5.4.1 L3 MPM1000

RUGGEDIZED MPM-1000 IP MODEM

Connect, Collaborate, Communicate – Anytime, Anywhere

L-3 Linkabit continues to meet the demand for Network Centric Satellite IP communications by providing the most powerful and advanced MPM system to date. The Ruggedized MPM-1000 (RMPM) modem hosts the Network Centric Waveform (NCW), the standard wide-band SATCOM waveform for both tactical military and commercial operations.

The RMPM-1000 NCW modem provides a fully automated network which requires no operator intervention to maintain connectivity, even during changing data link conditions. It enables full use of the advanced capabilities of the Wideband Global SATCOM (WGS) multi-beam, multi-band satellite.

The RMPM-1000 meets the networking needs of mobile, dispersed users such as: military, first responder, Non-Government Organization (NGO) or business enterprise personnel

KEY BENEFITS

Highly Dependable Mobile Communications

- Wide range of data rates, modulation schemes and FEC code rates
- Aggregate data throughput – 24.5 Mbps Tx/49 Mbps Rx
- Multiple independent channels – 2 Tx/4 Rx
  – provides maximum flexibility and throughput
- Low-latency/jitter Voice-over-IP (VoIP)
- Fine resolution, automated link power and data-rate control maintains connectivity in rapidly changing environments and seamlessly accommodates different terminal types and sizes
- Operates over any commercial or military transponded satellite (C-, X-, Ku- or Ka-band)

RUGGEDIZED MPM-1000 IP MODEM

L3

SPECIFICATIONS

MF-TDMA NETWORK CENTRIC WAVEFORM	
Data rate	32 Kbps to 13 Mbps (per channel) 26 Mbps Tx/52 Mbps Rx (aggregate)
FEC coding	Turbo SCCC and LDPC
FEC block sizes	Turbo: 1280 bits LDPC: 640, 1280, 2560 and 5120 bits
Modulation formats	BPSK: Rate ½ (Turbo & LDPC) OQPSK: Rate ½, ⅔ and ⅘ (Turbo) Rate ½, ⅔, ⅘ and ⅚ (LDPC) 8 PSK: Rate ⅔ (Turbo and LDPC)
Direct sequence spreading gain	0 to 12 dB (spread factors 1, 2, 4, 6, 8, 12, 16; up to 8.192 Mcps)
Number of independent carriers (MF-TDMA operation)	2 Transmit; 4 Receive Rapidly tunable over 1.2 GHz
Transmission security	AES-256 CBC TRANSEC (user data and control) FIPS 140-2 Level 2 certified
Control	SNMP V3/L-3 Linkabit HCI
ENVIRONMENTAL	
Conduction cooled and environmentally sealed	
Operating temperature	-6 °C to +50 °C
Storage temperature	-40 °C to +71°C
Vibration/shock	MIL-STD-810
EMI	MIL-STD-461
MECHANICAL/ELECTRICAL	
Size	1U 19 in. rack-mountable chassis 18.5 in. L x 19 in. W x 1.75 in. H
Weight	19 lb. (excluding mounting hardware)
Input power	90 to 264 VAC, 47 to 63 Hz
Power consumption	< 85 W
Frequency reference	Internal or external (5 or 10 MHz)
Intermediate frequency (with 10 MHz reference)	Tx (950 to 2150 MHz, threaded TNC) Rx (950 to 2150 MHz, threaded TNC)
BASEBAND INTERFACES	
Monitor/Control	10/100/1000 Ethernet (NCW and FDMA control) RS-485 (FDMA control)
NCW data port	10/100/1000 Ethernet
FDMA data port	MIL-STD-188-114/RS-422/RS-423
MIL-STD-188-165A (FDMA) COMPLIANT	
Type I	BPSK: 64 to 6000 kbps QPSK/OQPSK: 64 to 8472 kbps

FEATURES

Enables NCW Capabilities

- Supports full-mesh, hub-spoke and hybrid topologies
- Hub-assist mode maintains communications when conditions prevent peer-to-peer links
- Dynamic multicast: bandwidth efficient handling of multicast and broadcast packets

Excellent Support for On-The-Move (OTM)

- Rapid acquisition/reacquisition of network connection after blockage
- Supports Doppler, Doppler-rate and Doppler acceleration requirements for high-speed OTM performance
- Link-layer assured delivery (ARQ)

Operational Flexibility

- Stores preset mission configurations for simplified field operations and rapid start-up
- Any RMPM can take over as hub/network controller
  – no special hardware needed
- RMPM stacking capability provides increased throughput for a hub or a high-traffic node
- Implements Network Centric Waveform (NCW) MIL-STD-188-EEE and NATO STANAG 4707

WGS-Compliant – Leverages Capabilities of Advanced Wideband Satellites

- 1.2 GHz agile tuned front-end allows back-to-back bursts scheduled across wideband transponders/beams
- Multibeam operation with cross-banded allocations
  – uplink and downlink can be in different bands and beams
- Multibeam fan-in/fan-out capabilities
  – supports multicast and broadcast information streams

Efficient Use of Satellite Resources

- Floating carriers
  – no need to fix carrier frequency or pre-plan bandwidth allocation
- Automatic handover of control keeps network running under adverse conditions
- Simultaneous support for spread and non-spread users

L-3 Linkabit
9890 Towne Centre Drive
San Diego, CA 92121
Tel: 858.552.9555
Fax: 858.552.9668
Product Service Help Desk: 800.331.9401
Email: LinkabitProducts@L-3com.com
www.L-3com.com/Linkabit

5.4.2 iDirect

iDIRECT VELOCITY™ OVERVIEW

iDirect Velocity™ is an IP-based satellite communications system engineered to deliver high-quality broadband connectivity wherever and whenever it is needed. iDirect Velocity™ consists of an operating software, hub platform, network management system, and remote portfolio.

Operating Software
iDirect Velocity™ is the underlying operating software and manages all aspects of the platform. It builds on the capabilities of Evolution® for greatly expanded scale and is specifically designed for satellite operators to deploy managed HTS architectures. It consists of three main differentiators; an ability to manage a single bandwidth pool across multi-spot beam capacity globally, mobility capabilities in a multi spot-beam environment and the support for carrier-grade reliability and resiliency.

Flexible Hub Architecture
iDirect Velocity™ is comprised of a powerful, modular hub architecture to manage large HTS satellites consisting of more beams and frequencies, along with higher throughput. The hub architecture supports multiple satellite bands including Ka, Ku, C and X bands, enables multiple networking technologies and is optimized for offering different forms of managed service offerings. The line cards and hub components can handle much higher aggregate symbol rates, feature very efficient MODCODs and are hardware-ready for future DVB-S2x support.

Network Management System
iDirect Pulse™ enables satellite operators and service providers to expertly manage complex, large-scale networks; run an efficient, reliable and profitable network operation; and continually improve customer satisfaction. iDirect Pulse™ features open APIs to easily integrate with other OSS/BSS systems.

Remote Portfolio
The platform offers a range of satellite remotes designed to meet distinct end-user requirements supporting larger throughput and speeds. iDirect remotes come in multiple form factors, including desktops, rack-mounts and router boards that can be integrated into aeronautical, portable and other specialized communications systems.

Hub System
- Support for high aggregate Msps rates and highly efficient MODCODs
- Manage blended portfolio of frequencies and beam sizes
- Provides total hub redundancy due to centralized infrastructure

High Throughput Satellite
- Support for larger frequency ranges/ Ka/ Ku/ C/ X-band
- DVB-S2/ACM and Adaptive TDMA
- Mobility/ faster beam switching
- Global Bandwidth Mgmt of SLAs across multi-spot beams

Remote
- High performance remotes
- Dual mode-remote to operate on blended portfolio

Network Management System
- Scalability and efficient NOC operation
- Higher visibility for customers through Portal
- Open APIs for OSS/BSS integration

DIFFERENTIATING **FEATURES**

Managing HTS bandwidth across multiple spot beams presents a distinct set of challenges for satellite operators. With iDirect Velocity™, satellite operators can rely on the renowned features of the iDirect platform plus additional differentiating features that allow them to transform their business in order to meet the unique requirements of operating in an HTS environment.

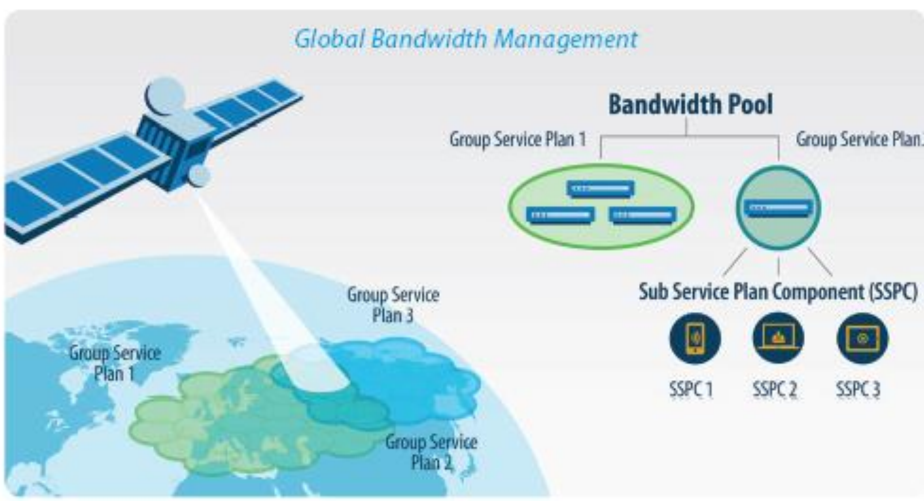
Global Bandwidth Management

Global Bandwidth Management (GBWM) enables satellite operates to manage a single bandwidth pool across a large coverage area spanning multiple spot beams.

GBWM consists of Quality of Service (QoS) management features that allow for bandwidth partitioning into multiple service tiers across the entire payload, managing contention among service providers and end-customers. A satellite operator offering managed bandwidth can create sub-networks and groups of remotes based on Mbps with various levels of service plans.

Often, the beams will not be evenly loaded in all parts of the coverage at all times, in which case the operator also has the flexibility to restrict a service offering to certain geographic areas, or to certain times of the day. Such features as Load Balancing, Service Scheduling, Geoscope and Fair Access Policy (FAP) help to better manage congestion and optimize fill rates.

Multiple spot beams can be grouped into Global Service Plans (GSP) and further partitioned into sub GSPs for different service providers. Each service provider can be in control of setting their own service parameters and divide



Protecting the network from service degradation, service interruptions or from catastrophic events is key to ensuring a very high availability and reliability of the HTS network.

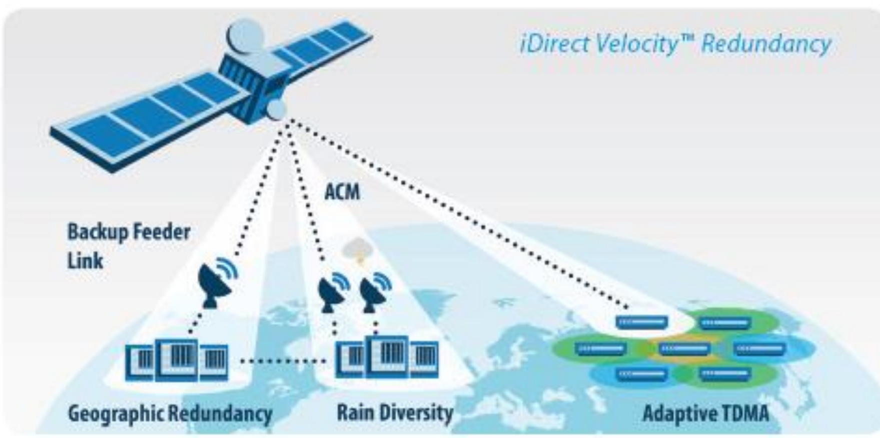
Since Ka-band frequencies are particularly prone to rain fade, iDirect Velocity™ leverages adaptive modulation techniques, such as Adaptive Coding and Modulation (ACM) and Adaptive TDMA to achieve the maximum data throughput and optimized traffic in changing weather conditions.

The platform features built-in high reliability on all aspects of hub infrastructure, ranging from very high line card availability and hub component redundancy, to rain diversity and complete gateway redundancy.

iDirect Velocity™ hub components feature a high **line card availability** using a cluster architecture with failover and load sharing schemes between components within the hub network architecture.

Rain diversity is a form of switchover to a geographically diverse hub location during a time of service degradation at the primary location due to changing weather conditions. The moment weather conditions improve, the rain diversity architecture automatically shifts back to the prime hub location without any noticeable service interruption to the end-users since the terminals stay in the network the entire time.

iDirect Velocity™ also enables complete **geographic redundancy** protecting the network from a loss of service for an extended period of time in the event of a catastrophic failure at the primary gateway. This requires access to a fully equipped failover hub system in a geographically different location to enable a complete, fast switchover at the IP interface level between the subsystems.



5.4.3 Hughes

Hughes Airborne Satcom System

HUGHES

Airborne Microsat Modem

The Hughes Airborne SATCOM System is an integrated defense-class solution providing a constant and reliable feed of critical real-time information to support any mission. Ideal for Beyond-Line-of-Sight (BLOS) connectivity requirements, it is powered by the innovative Hughes Airborne Microsat Modem and antenna that connect the airborne platform to the satellite and then to one or more ground stations.

Designed with an open architecture, this modem is a Commercial-off-the-Shelf (COTS) solution that can be readily installed into a wide range of manned and unmanned, fixed or rotary winged platforms. Based on a unique Software Defined Radio (SDR) employing the specialized Hughes Scrambled Code Multiple Access (SCMA)* waveform, it delivers a superior level of mobile video, voice, and data capabilities for airborne BLOS systems. Packaged in only half of a standard Airborne Transportable Rack (ATR), the ruggedized modem is compatible with all standards-based antennas and is a fully compliant member of the market-leading Hughes HX System family.

Benefits

- High data throughput for BLOS applications
- Scrambled Code Multiple Access (SCMA) waveform
- Transmit/receive through rotary blades
- Transmit/receive on fixed wing platforms
- Flight dynamics flexibility at high velocity and high acceleration
- Very short acquisition and reacquisition time
- Open architecture for use with any airborne antenna
- Low power consumption
- Frequency reuse

www.hughes.com

Hughes Airborne Satcom System

Features:

- Half ATR ruggedized chassis, mounting tray
- Mil-spec Compliant (vibration, temperature)
- Interoperable with HX system or SCMA
- Integrated Internal DC/DC power supply
- GUI for Management and Control
- Separate Data and M&C ports

***About Hughes Microsat SCMA Waveform:** The advanced Hughes SCMA waveform (AMW) was developed expressly to provide robust, efficient, and secure BLOS connectivity over satellites for Fixed Wing, Rotary Wing, and UAS platforms. The waveform optionally includes Upper-Layer Protocol Enhancements (ULPEs) for high-speed transmission with zero packet loss through rotating blades. Additionally, there is an outer code that offers protection for flight-critical data and can also be used to protect against intentional jamming or other types of interferences. The low-rate inner code of AMW allows multiple users to efficiently share the same bandwidth by using specific scramblers per user. Other advantages include a strong capability to maintain carrier lock and frame synchronization with a broad range of code rates for capacity adaptation. AMW technology is especially well-suited for operating over satellites employing extremely small antennas (Microterminals), with potential applications such as tactical communications on-the-move, asset tracking, sensor networking, and smart grid.

Technical Specifications

Weight
15.5 lbs

Dimensions
12.675 in x 7.62 in x 4.88 in

Temperature
-10° C to 60° C, with derating for altitude
MIL-STD-810F temperature compliant

Altitude
-500 ft to 25,000 ft

Vibration
RTCA/DO-160E, Section 8.4

Shock
Designed to meet Crash Hazard – Method 516.6, Procedure V

Power consumption
Average power consumption of ~80 W
28 VDC Input (18 to 32 VDC range)

Throughput
10 Mbps to 19 Mbps

For more information, visit defense.hughes.com or call 301-428-2762.

www.hughes.com

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