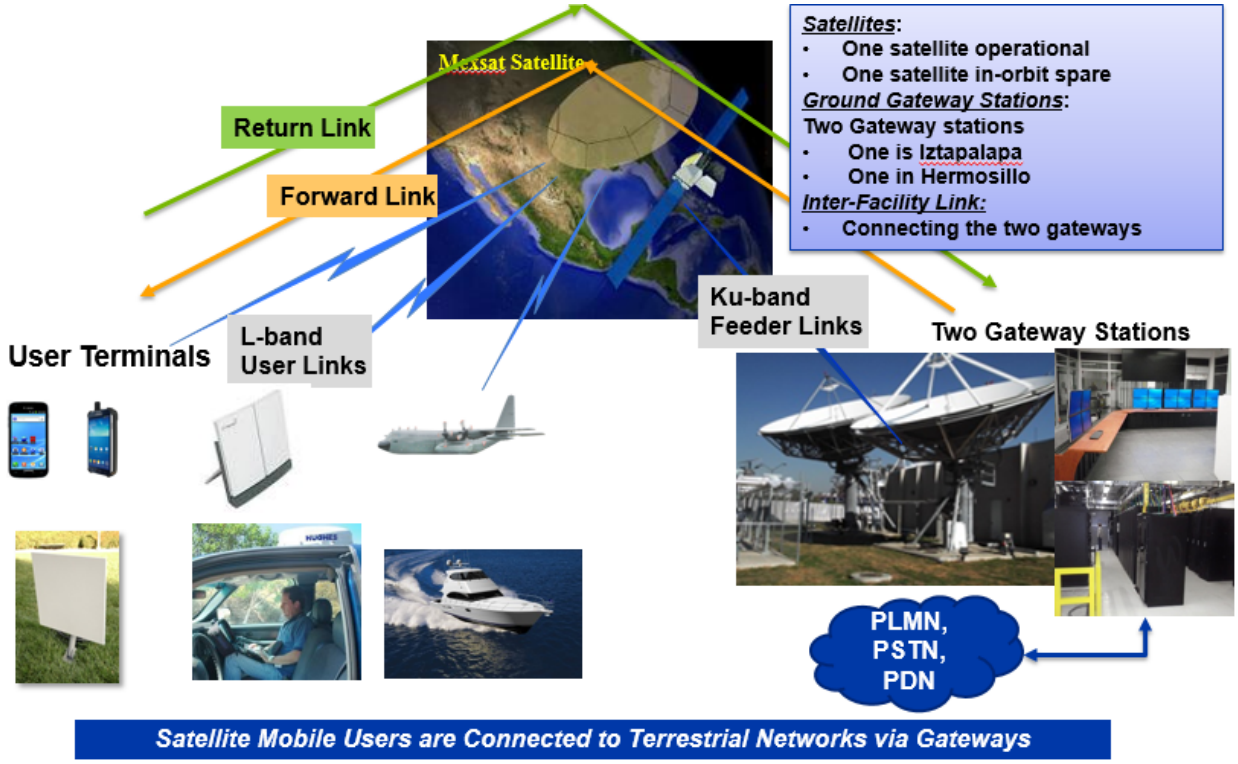
Mexsat RUT Temporary Operation Application Supplement

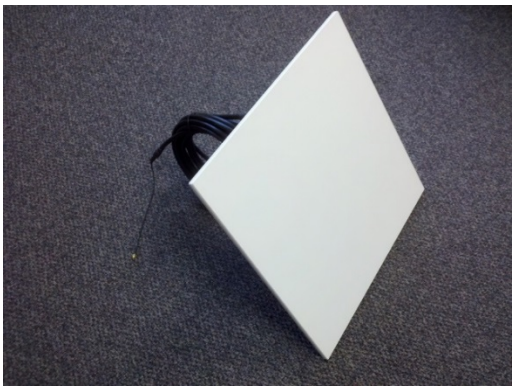
Introduction

The Boeing 702HP Mexsat mobile communication system provides end-to-end services to users with three major segments. The Space Segment consists of a 22 meter L-band reflector and digital payload. The Ground Segment has two gateways and a Network and Satellite Operations Center and L-Band User Terminals.



Boeing is applying to FCC for a temporary license to operate an L-Band terminal at the El Segundo facility. Three types of Hughes Network System (HNS) manufactured Mexsat Reference User Terminals (RUT) are planned for over the air test at El Segundo, CA. A Mexsat RUT consists of a modem, an L-Band antenna, and a GPS antenna. Depending on the RUT type, the GPS antenna can be integrated as part of the RUT antenna or standalone antenna placed next to the RUT antenna. The Mexsat system requires the GPS location of the RUT to assign appropriate carriers per a pre-defined system resource plan.

The pictures for the antenna types are provided below. The modem connected to the antenna is common to the antenna. The RUT characteristics are listed in the following pages.



Front of Semi Fixed Antenna (19 sq in)

Back of Semi Fixed Antenna

Picture of the Portable Antenna undergoing IP5X dust test

Picture of Hand Held Stub Antenna

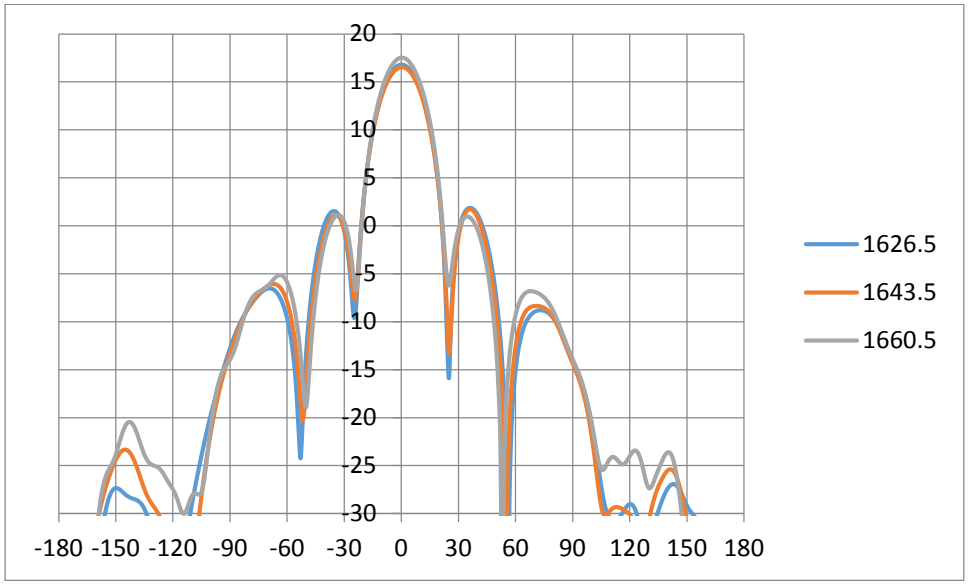
For the upcoming system test, the Mexsat system (RUT) will only operates at the frequencies listed in the table. These frequencies have been coordinated with Mexsat as well as other regional satellite operator such as Inmarsat. The Boeing temporary frequency application request is with the Ground Terminal Transmit as enclosed in the red square for both LHCP and RHCP.

Ground Terminal Receive			Ground Terminal Transmit		
Start Freq (MHz)	Stop Freq (MHz)	Bandwidth (MHz)	Start Freq (MHz)	Stop Freq (MHz)	Bandwidth (MHz)
1526.300000	1526.800000	0.500000	1627.800000	1628.300000	0.500000
1527.330000	1528.250000	0.920000	1628.830000	1629.750000	0.920000
1528.680000	1529.200000	0.520000	1630.180000	1630.700000	0.520000
1529.535000	1529.560000	0.025000	1631.035000	1631.060000	0.025000
1529.700000	1529.950000	0.250000	1631.200000	1631.450000	0.250000
1529.950000	1530.000000	0.050000	1631.450000	1631.500000	0.050000
1530.450000	1530.700000	0.250000	1631.950000	1632.200000	0.250000
1530.700000	1530.750000	0.050000	1632.200000	1632.250000	0.050000
1532.900000	1533.100000	0.200000	1634.400000	1634.600000	0.200000
1533.200000	1533.420000	0.220000	1634.700000	1634.920000	0.220000
1548.550000	1548.750000	0.200000	1650.050000	1650.250000	0.200000
1548.900000	1549.050000	0.150000	1650.400000	1650.550000	0.150000
1558.500000	1559.000000	0.500000	1660.000000	1660.500000	0.500000
	Total Spectrum	3.835000		Total Spectrum	3.835000

Coordinated RUT Transmit Frequency Table

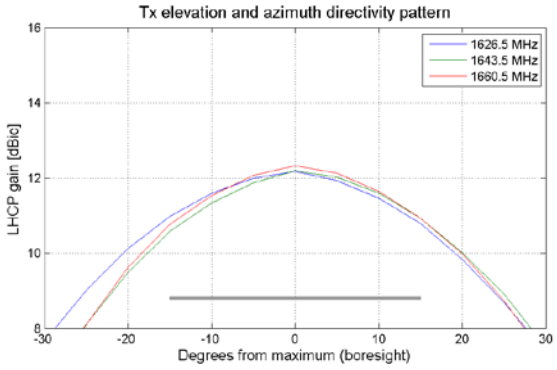
Characteristics of the RUT antennas

1. Semi Fixed RUT – The test plan calls for a single Semi Fixed antenna to be installed on the Boeing El Segundo S30 roof top (2 stories). The transmit antenna pattern sourced from the HNS test report is provided below.

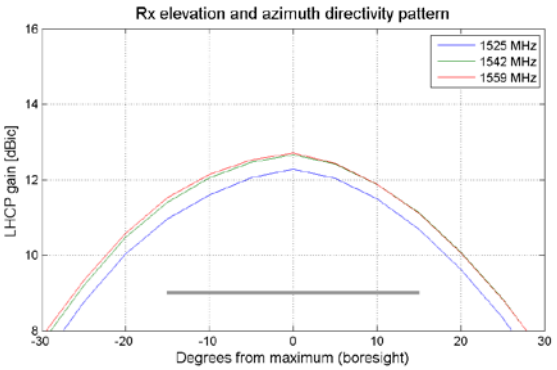


Semi Fixed Antenna transmit radiation pattern 180 degrees around boresight

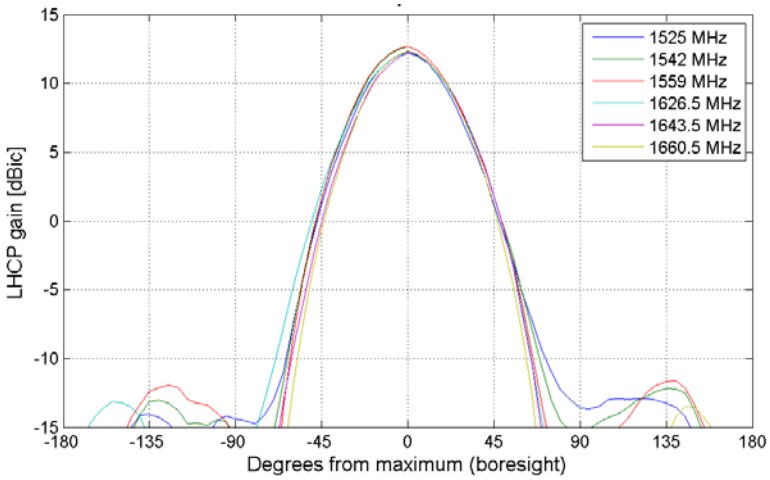
2. Portable RUT – antenna pattern for transmit and receive are provided below. The wider spatial scan contains both transmit and receive pattern.



Portable RUT Antenna Tx Patterns



Portable RUT Antenna Rx Patterns



Portable RUT Tx and Rx Patterns (+/- 180° Span)

3. Hand Held Stub Antenna - antenna pattern for transmit and receive are provided below.

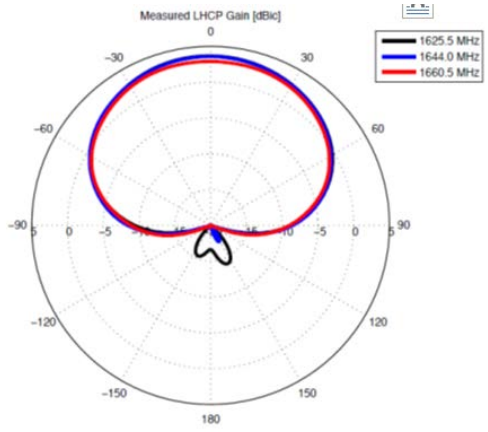


Figure 3-4 Transmit radiation pattern ϕ=0 deg

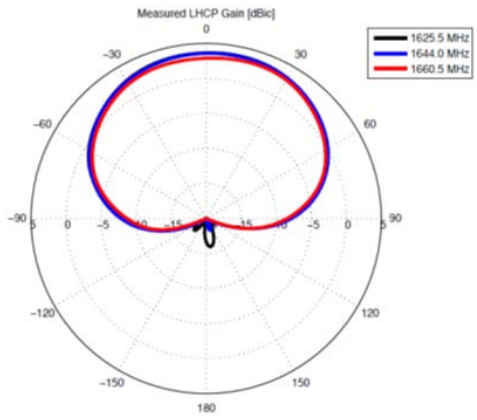


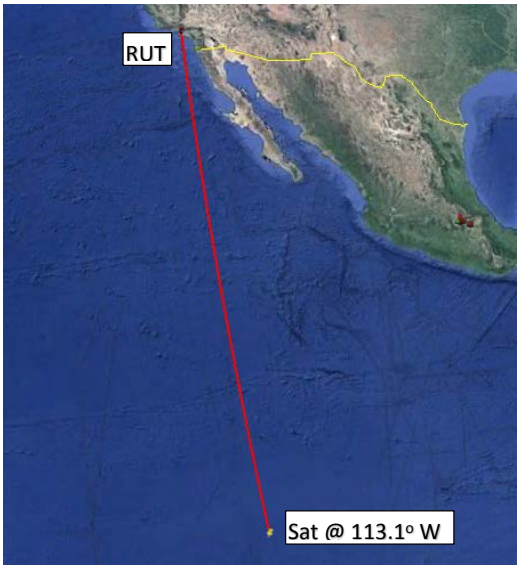
Figure 3-5 Transmit radiation pattern ϕ=90 deg

Hand Held RUT Tx Patterns

4. Interference Analysis

4.1 Background

Mexsat F1 orbital location: 113.1° W. Ground terminal pointing to the satellite: (170.747° Az, 50.584° El).



The current plan is to locate the Semi Fixed RUT on the roof top as indicated. The Portable and HH RUT will be tested on the Boeing parking lot on the ground level with the building providing additional isolation to the airport. Distance from the roof top Semi Fixed RUT terminal to the closest parked aircraft in LAX is 350 meter.

Distance from the RUT to the closest parking aircraft in LAX

4.2 RUT Performance

HNS designed and tested the Mexsat RUT to European Telecommunication Standards Institute Standard, (ETSI) EN 301 444 V1.2.2 (2013-06). All the major satellite terminal manufacturers designed handset to this standard. The specification for the spurious transmission is covered under Table 2c: Limits of unwanted emissions above 1 000 MHz and outside the band 1 625,8 MHz to 1 661,2 MHz and the band 1 667,3 MHz to 1 675,7 MHz.

Frequency range (MHz)	Carrier-on		Carrier-off	
	EIRP limit (dBpW)	Measurement bandwidth (kHz)	EIRP limit (dBpW)	Measurement bandwidth (kHz)
1 000,0 to 1 518	60	1 000	48 (note 7)	100
1 518,0 to 1 525,0	60	1 000	17	3
1 525,0 to 1 559,0	49	100	17	3
1 559,0 to 1 580,42	50	1 000	50	1 000
1 580,42 to 1 605,0	50	1 000	50	1 000
1 605,0 to 1 610,0	(note 5)	100	(note 6)	100
1 610,0 to 1 625,8	74	100	48	100
1 625,8 to 1 661,2	(note 1)	(note 1)	(note 1)	(note 1)
1 661,2 to 1 661,7	(note 8)	100	48	100
1 661,7 to 1 666,8	74	100	48	100
1 666,8 to 1 667,3	(note 9)	100	48	100

For GPS L1 carrier located at 1575.42 MHz, the 50 dBpW translated into -40 dBm for the 1 MHz measurement bandwidth. To compliance with GPS, the ITU-R Recommendation ITU-R M.1903 (01/2012) specified -147 dBW (-117 dBm) for interference threshold over 1 MHz bandwidth for Precision approach and Satcom equipped, Figure 2, Threshold values of interference for FDMA receivers.

The following analysis shows an isotopic RUT (Hand Held) transmitter's performance to an isotopic antenna per GPS.

Analysis assumptions (yellow highlighted cells):

GPS receive antenna size is 30 sq cm

RUT output power noise performance of -40 dBm per ETSI specification cited earlier.

Parameter	Reference	Distance [m]	Rx [dBm]		
-40	Interference power in 1 MHz [dBm]	Distance [m]	Isotopic	Semi-Fixed	Portable
0.05	antenna width (square) [m]	10	-97.01	-142.01	-121.01
		20	-103.03	-148.03	-127.03
-123.00	GPS allowable spec for Interference threshold	40	-109.05	-154.05	-133.05
	per ITU-R Recommendation ITU-R M.1903 (01/2012)	80	-115.07	-160.07	-139.07
	-147 dBW [-117 dBm] over 1 MHz	160	-121.10	-166.10	-145.10
	Adding 6 dB safety margin normally applied by ICAO	320	-127.12	-172.12	-151.12
		640	-133.14	-178.14	-157.14
		1280	-139.16	-184.16	-163.16
		2560	-145.18	-190.18	-169.18
		5120	-151.20	-196.20	-175.20
	Front to back isolation (dB) for directional antenna			-45	-24
-1.212E-05	Target for goal seek (what-if)	199.2	-123		
*Received interference power [dBm] <--from isotropic transmitter to square GPS receive antenna with 500K temp					

This is a worse case analysis result (separation of 199.2 meters) that applies to an isotopic antenna. The current distance from the RUT to the closest parked aircraft is 350 meters. As stated previously, the Portable and HH RUTs will be tested on a temporary basis in the Boeing parking lot with building in-between the RUT and airport to provide additional signal attenuation. The Portable RUT has additional 24 dB isolation from antenna pointing. The minimum separation for the Portable RUT to a GPS receiver is 12.6 meters.

For the Semi Fixed RUT, the interference is further attenuated by the directivity of the antenna being pointed to the satellite at 113.1^{o} west. The direction is close to 180^{o} away from LAX. The pointing away from the airport provides a minimum of 45 dB additional spatial isolation (beam peak 0^{o} to 150^{o}) to the analysis result. There should be no detectable Semi Fixed RUT signal for a GPS receiver in the LAX.

4.3 Conclusion

The analysis showed that the level for each RUT type and the test environment is compatible with GPS operation with margin. The Mexsat L-band RUT is designed to the international standard that is the basis for the major satellite operator and equipment currently in use in LAX and around the world.