Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Application of	)	
DIRECTV ENTERPRISES, LLC	)	File No. ______________
Application for Authorization to Launch And Operate DIRECTV RB-79W, a Satellite in the 17/24 GHz Broadcasting Satellite Service at 79° W.L.	)	Call Sign:

APPLICATION FOR AUTHORIZATION TO LAUNCH AND OPERATE DIRECTV RB-79W, A SATELLITE IN THE 17/24 GHz BROADCASTING SATELLITE SERVICE

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APPLICATION FOR AUTHORIZATION TO LAUNCH AND OPERATE DIRECTV RB-79W, A SATELLITE IN THE 17/24 GHz BROADCASTING SATELLITE SERVICE

DIRECTV Enterprises, LLC ("DIRECTV") hereby requests authority to launch and operate a satellite to be known as DIRECTV RB-79W in the 17/24 GHz Broadcasting Satellite Service ("17/24 GHz BSS") at the nominal 79° W.L. orbital location. A completed Form 312 and accompanying Schedule S related to this application are attached. DIRECTV intends to use this satellite to provide high quality direct-to-home ("DTH") satellite service, including high-definition ("HD") video programming, throughout Mexico. This application provides the information required by the Commission's rules in support of the proposed satellite authorization. Expeditious grant of this application will enable DIRECTV to extend its leadership in digital home video entertainment innovation in Mexico.

I. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

Since initiating service in 1994, DIRECTV has become the leading provider of DTH digital television services in the United States, with over 20 million subscribers. It currently has a fleet of eleven in-orbit spacecraft operating in the Ku BSS, Ka FSS, and 17/24 GHz BSS bands which have enabled DIRECTV to maintain and extend its leadership in high definition ("HD") services and set the stage for introduction of UltraHD services as well. Its affiliate, DIRECTV Latin America ("DTVLA"), is the leading provider of DTH digital television services throughout Latin America, serving more than 19 million subscribers in over 10 countries using Ku-band satellites. This includes approximately 6.6 million subscribers served by DTVLA's affiliate Innova, S. de R.L. de C.V., commonly referred to as Sky Mexico, which is growing significantly each year despite intensifying competition. These companies strive to combine unique and compelling content with technological innovation and industry-leading customer service to make DIRECTV and DTVLA the clear choice among consumers throughout the Americas.

This application seeks launch and operating authority for a new 17/24 GHz BSS spacecraft at the nominal 79º W.L. orbital location, which DIRECTV intends to use to expand its DTH capabilities still further in order to support the ongoing transition to HD services in Mexico. Transmitting programming in HD format requires significantly more capacity than transmitting the same programming in SD format. As more programmers migrate to HD, DIRECTV will need to make sure that its system has the additional capacity available to handle the demands of an increasingly robust slate of HD content. The need for additional capacity is especially acute in Mexico, and DIRECTV's ability to combine Ku-band and 17/24 GHz BSS satellite capacity from the same slot would ease the transition to this new frequency band.

Granting this application will serve the public interest in several ways. First, the Commission will enable DIRECTV, and its affiliate DTVLA, to increase the amount of HD programming available to subscribers in Mexico. Second, the ability to keep pace with HD programming demands will make DTVLA better able to compete against cable and telco multichannel video services in Mexico. Third, the rich and varied HD services offered from this orbital location will give subscribers additional incentive to upgrade to digital television sets, further promoting the digital transition.

For all of these reasons, DIRECTV submits that the Commission should grant this application as expeditiously as possible.

II. Information Required Under Sec. 25.114 of the Commission's Rules

1. Name, Address, and Telephone Number of Applicant

DIRECTV Enterprises, LLC
2230 East Imperial Highway
El Segundo, CA 90245
(310) 964-0700

2. Name, Address, and Telephone Number of Counsel

William M. Wiltshire
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Washington, DC 20036
(202) 730-1300

3. Type of Authorization Requested

DIRECTV hereby applies for authority to launch and operate a new 17/24 GHz BSS satellite, DIRECTV RB-79W, which is a 17/24 GHz BSS payload on the already authorized and constructed DIRECTV KU-79W satellite. DIRECTV RB-79W will provide BSS service in the 17 GHz BSS band and will augment the capabilities of the DIRECTV Latin America affiliate, SKY Mexico, to provide competitive MVPD services to subscribers across Mexico.

DIRECTV recognizes that the orbital location it seeks is slightly offset from the presumptive "on-grid" slot at 79° W.L. established in Appendix F of the *BSS R&O*[1] (an "Appendix F slot"). However, as there are no other 17/24 GHz BSS licensees within four degrees of the requested location, it seeks authority to operate with full power and full interference protection, as contemplated in Sections 25.114(d)(15)(iii) and 25.262(b) of the Commission's rules.[2]

4. General Description of Overall System Facilities, Operations and Services

DIRECTV RB-79W will consist of a 17/24 GHz BSS payload on the already authorized and constructed DIRECTV KU-79W satellite located at the nominal 79° W.L. orbital location,[3] and associated ground station equipment. DIRECTV RB-79W is designed to provide DTH service in Mexico in the ITU Region 2 BSS band and its associated feeder link band (*i.e.*, 17.3-17.8 GHz (space-to-Earth) and 24.75-25.25 GHz (Earth-to-space)).

The DTH service will be provided to millions of customers in Mexico using relatively small receive antennas. As this is a payload on the DIRECTV KU-79W

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1 *See Establishment of Policies and Service Rules for the Broadcasting Satellite Service at the 17.3-17.7 GHz Frequency Band and at the 17.7-17.8 GHz Frequency Band Internationally, and at the 24.75-25.25 GHz Frequency Band for Fixed Satellite Services Providing Feeder Links to the Broadcasting-Satellite Service and for the Satellite Services Operating Bi-directionally in the 17.3-17.8 GHz Frequency Band*, 22 FCC Rcd. 8842, Appendix F (2007).

2 *See* 47 C.F.R. §§ 25.114(d)(15)(iii) and 25.262(b). The Commission revised the rules so that an operator offset by up to one degree from an Appendix F slot would not have to reduce power or accept additional interference if there were no other applicant or licensee at the adjacent Appendix F slot. *See Establishment of Policies and Service Rules for the Broadcasting-Satellite Service at the 17.3-17.7 GHz Frequency Band and at the 17.7-17.8 GHz Frequency Band Internationally, and at the 24.75-25.25 GHz Frequency Band for Fixed Satellite Services Providing Feeder Links to the Broadcasting-Satellite Service and for the Satellite Services Operating Bi-directionally in the 17.3-17.8 GHz Frequency Band*, 22 FCC Rcd. 17951, ¶ 22 (2007).

3 *See* Grant Stamp, IBFS File Nos. SAT-LOA-20120316-00051 and SAT-AMD-20120420-00071 (July 12, 2012).

satellite, the Telemetry, Tracking and Control ("TT&C") functions will be provided at the edges of the conventional Ku-band.

DIRECTV RB-79W can broadcast on up to twenty-four frequencies supporting Mexican national beam transmissions. All twenty-four channels will have a usable bandwidth of 36 MHz.

5. Operational Characteristics

5.1 Frequency/Channelization and Polarization Plan

Details of the DIRECTV RB-79W frequency/channelization and polarization plan, except for TT&C frequencies, are included in the accompanying Schedule S, which is hereby incorporated by reference as if fully set forth herein.[4] All uplink channels will be fed to DIRECTV RB-79W from locations in Mexico, or from DIRECTV uplink facilities in the United States. The emission designator for the uplink and downlink communications signals will be 36M0G7W and the allocated bandwidth for these emissions is 36 MHz.

5.2 Communications Payload

5.2.1 Uplink Transmissions

The maximum receive antenna gain and maximum G/T of the DIRECTV RB-79W satellite are specified in the accompanying Schedule S. Note that the G/T will decrease, dB-for-dB, from the maximum as the uplink location moves away from beam peak.

5.2.2 Downlink Transmissions

The DIRECTV RB-79W downlink will be capable of a maximum EIRP of 52.5 dBW. The peak transmit antenna gain and associated contours are specified in the

[4] As DIRECVTV RB-79W is a payload on the DIRECTV KU-79W satellite, the relevant TT&C details can be found in IBFS File Nos. SAT-MOD-20140902-00098 and SAT-MOD-20150422-00029.

accompanying Schedule S. The received and frequency translated signals will be amplified by microwave power modules with selectable fixed/Automatic Level Control (ALC) modes prior to final amplification. The fixed gain mode will have at least 19 dB of gain adjustment with a step size of approximately 0.5 dB. The ALC will hold the output level constant over an input dynamic range of at least 15 dB and will have a minimum output level adjustment of 10 dB in 0.5 dB increments.

5.3 TT&C Subsystem

As DIRECTV RB-79W is a payload on the DIRECTV KU-79W satellite, a description of the TT&C subsystem is included in the application for DIRECTV KU-79W.[5]

6. Orbital Locations

DIRECTV seeks to locate the DIRECTV RB-79W satellite at 78.8° W.L. orbital location, where it will be a payload on the DIRECTV KU-79W satellite. Physical coordination of DIRECTV RB-79W is addressed in the application for DIRECTV KU-79W.

7. Predicted Spacecraft Antenna Gain Contours

7.1 Uplink Beams

The satellite will receive communications signals from facilities within Mexico and/or from DIRECTV uplink facilities in the United States. The receive antenna gain contours for the DIRECTV RB-79W receive beam is given in GXT format in the accompanying Schedule S.

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[5] *See* IBFS File Nos. SAT-LOA-20120316-00051, SAT-AMD-20120420-00071, SAT-MOD-20140902-00098, and SAT-MOD-20150422-00029.

7.2 Downlink Beams

DIRECTV RB-79W will employ a single transmit antenna system for 17/24 GHz BSS service to provide Mexican national coverage and will be capable of transmitting across the frequency band 17.3-17.8 GHz using LHCP and RHCP. The peak transmit gain, and the antenna gain contours in GXT format, are given in the accompanying Schedule S. The gain contours are also graphically depicted in Figure 7-1 below.

Figure 7-1. DIRECTV RB-79W Transmit Antenna Gain Contours

The predicted and measured far off-axis gain performance for this 17 GHz transmit antenna is addressed in Appendix B of this application.

7.3 TT&C Beams

As DIRECTV RB-79W is a payload on the DIRECTV KU-79W satellite, a description of the TT&C beams is included in the application materials for DIRECTV KU-79W.[6]

8. Service Description, Link Performance Analysis, and Earth Station Parameters

8.1 Service Description

DIRECTV will use the DIRECTV RB-79W satellite to retransmit digital video and audio entertainment, educational and informational programming to subscribers throughout Mexico.

8.2 Link Performance

A representative communications link budget for the DIRECTV RB-79W satellite is shown in Appendix A. Because DIRECTV is applying for an orbital location that is offset 0.2° from an Appendix F slot, these budgets include an entry for adjacent satellite interference ("ASI") from neighboring 17/24 GHz BSS satellites nominally spaced 3.8º, 4.2º, 7.8º and 8.2º away. The TT&C link budgets are included in the application for DIRECTV KU-79W.

[6] *See* IBFS File Nos. SAT-LOA-20120316-00051, SAT-AMD-20120420-00071, SAT-MOD-20140902-00098, and SAT-MOD-20150422-00029.

8.3 Earth Station Parameters

There are essentially two types of earth stations to be used with the DIRECTV RB-79W satellite: feeder-link earth stations and subscriber terminals. The feeder-link stations will be relatively large transmit antennas, typically 9 to 13 meters, that track the satellite electronically and will be used for transmitting programming material from SKY Mexico or DIRECTV transmit facilities to the satellite. The subscriber terminals for reception in Mexico will be relatively small (90 cm) antennas located at subscribers' premises.

9. Satellite Orbit Characteristics

The DIRECTV RB-79W satellite will be maintained in geosynchronous orbit at the 78.8º W.L. orbital location with a maximum N-S drift of ± 0.05°, and a maximum E-W drift of ± 0.05°. The antenna axis attitude will be maintained within a time-weighted 3σ value of ± 0.1° for all modes of operation.

10. Power Flux Density

The allowable PFD levels in the 17.3-17.7 GHz band are defined in Section 25.208(w) of the Commission's rules on a regional basis for all conditions, including clear sky, and for all methods of modulation as:

(1) In the region of the contiguous United States, located south of 38º North Latitude and east of 100º West Longitude: -115 dBW/m^2/MHz;

(2) In the region of the contiguous United States, located north of 38º North Latitude and east of 100º West Longitude: -118 dBW/m^2/MHz;

(3) In the region of the contiguous United States, located west of 100º West Longitude: -121 dBW/m^2/MHz; and

(4) For all regions outside of the contiguous United States including Alaska and Hawaii: -115 dBW/m^2/MHz.

As discussed in Section 5.2.2 above, the maximum downlink EIRP for DIRECTV RB-79W will be 52.5 dBW/36 MHz channel. DIRECTV calculates the maximum power flux density/MHz on the Earth's surface from this emission as: Max EIRP/channel minus spreading loss in direction of max gain minus bandwidth correction factor, or 52.5 dBW/36MHz – 162.4 (dB-m^2) – 10log(36) = -125.5 dBW/m^2/MHz. This value is lower than even the lowest regional limit above and, as such, DIRECTV RB-79W is compliant with Section 25.208(w). DIRECTV RB-79W will also operate in the 17.7-17.8 GHz band and the maximum allowable PFD at the Earth's surface for this frequency band is specified in Section 25.208(c) on an angle-dependent basis. The lowest PFD limit in this rule, for the lowest angle of arrival, is -115 dBW/m^2/MHz and, as demonstrated above, DIRECTV RB-79W is compliant with this value as well.

Because DIRECTV RB-79W will be placed at 78.8º W.L. rather than the Appendix F slot at 79° W.L., there will be 0.2º less spacing between DIRECTV RB-79W and the next closest on-grid location established in the *BSS R&O*. This slight offset results in approximately 0.5 dB less discrimination from this adjacent location.[7] The maximum PFD calculated above, which is 10.5 dB less than the highest and 4.5 dB less than the lowest limitation established in Section 25.208(w)(1), more than accounts for this slight reduction in discrimination from this next closest location as required under Section 25.140(b)(4)(iii). This means that the DIRECTV RB-79W system is necessarily compliant with the PFD levels established in Sections 25.208(c) and 25.208(w)(1) through (4).

7 This value is based on the reduction of topocentric angle and the assumption of a 45 cm receive antenna that meets the reference antenna pattern of Section 25.224.

11. Arrangement for Tracking, Telemetry, and Control

DIRECTV has contracted with Intelsat to perform TT&C operations for the DIRECTV KU-79W satellite, on which the DIRECTV RB-79W payload resides and it is planned that TT&C for DIRECTV KU-79W would be done in a manner similar to that of DIRECTV's existing satellites.

12. Common Carrier Status

DIRECTV intends to operate the DIRECTV RB-79W satellite on a non-broadcast, non-common carrier basis, as it operates its current DBS and Ka-band satellite capacity at its existing orbital locations. DIRECTV may sell and/or lease a portion of its capacity on a non-common carrier basis for complementary business purposes.

15. Schedule

DIRECTV has already contracted for, and constructed, the DIRECTV RB-79W payload as part of the DIRECTV KU-79W satellite.

16. Public Interest Considerations

See Section I above.

17. Interference Analysis

In order to achieve maximum compatibility between diverse networks, the Commission has established coordination thresholds for earth station off-axis EIRP density and spacecraft PFD in Sections 25.223 and 25.208, respectively. As such, DIRECTV has assumed for the purposes of this application maximum downlink PFD values from neighboring systems consistent with Section 25.208(w), maximum feeder link earth station off-axis transmit power density consistent with Section 25.223 and receive earth station compliance with Section 25.224 (*i.e.*, Recommendation ITU-R BO.1213).

The interference analyses that are included in this application were performed in conjunction with the end-to-end link performance analyses. An abbreviated link budget is presented in Appendix A. The analysis includes the effects of adjacent satellite interference from satellites nominally spaced 3.8º, 4.2º, 7.8º and 8.2º away in evaluating whether the system accommodates the anticipated data rate at acceptable C/(N+I) thresholds. Additionally, adjacent satellite interference was calculated assuming 0.5° mis-pointing of the receive antenna and 0.05° station-keeping of the interfering satellites. Appendix A demonstrates that the DIRECTV RB-79W satellite design described in this application is compatible with the aforementioned transmission parameters and interference environment. Accordingly, the proposed 17/24 GHz BSS satellite would operate successfully in such an environment.

To properly account for interference from adjacent operating satellite systems, the uplink budgets include aggregate interference from earth terminals associated with satellites at 3.8º, 4.2º, 7.8º and 8.2º of orbit separation. On the uplink, the budgets include a level of interference that accounts for the maximum level of off-axis EIRP permissible under Section 25.223. On the downlink, the satellites at 3.8º, 4.2º, 7.8º and 8.2º of orbit separation are each assumed to produce an interference level equivalent to the maximum PFD value permissible under Section 25.208(w). It is shown that the system, as proposed, will be able to successfully operate in this interference environment.

18. Orbital Debris Mitigation

As DIRECTV RB-79W is a payload on the DIRECTV KU-79W satellite, DIRECTV incorporates herein the full description of Orbital Debris Mitigation provided in the DIRECTV KU-79W application.[8]

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8 *See* IBFS File No. SAT-LOA-20120316-00051, Application at 14-18.

III. ITU COST RECOVERY

DIRECTV is aware that, as a result of the actions taken at the 1998 Plenipotentiary Conference, as modified by the ITU Council in 2005, processing fees are now charged by the ITU for satellite network filings. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU. DIRECTV hereby states that it is aware of this requirement and accepts responsibility to pay any ITU cost recovery fees associated with this application. Invoices for such fees may be sent to the contact representative listed in the accompanying FCC Form 312.

IV. CONCLUSION

The proposed space station will provide DIRECTV's Latin American affiliate, SKY Mexico, with a capable 17/24 GHz BSS satellite that will enhance its ability to provide high quality multichannel video service to millions of Mexican subscribers.

For these reasons, DIRECTV submits that the proposed satellite will serve the public interest and respectfully requests that the Commission expeditiously grant this request.

Respectfully submitted,

DIRECTV ENTERPRISES, LLC

By: __/s/________________________
Romulo Pontual
Executive Vice President

ENGINEERING CERTIFICATION

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

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

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

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

Signed:

/s/

Jack Wengryniuk

April 28, 2015

Date

APPENDIX A

LINK BUDGET ANALYSIS

Table A-1. DIRECTV RB-79W Link Budget

Mexico	Clear Sky	Rain Dn
Transmit power, dBW	15.0	26.7
Transmit power density dBW/Hz	-60.6	-48.9
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	64.7	64.7
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-212.4	-212.4
Atmospheric loss, dB	-0.2	-0.2
Uplink rain loss, dB	0.0	-11.7
Satellite G/T, dB/K	8.0	8.0
Bandwidth, dB-Hz	74.8	74.8
Boltzmann's constant, dBW/Hz K	228.6	228.6
	26.3	**26.3**
Satellite EIRP, dBW/36 MHz	52.5	52.5
Free space loss, dB	-209.3	-209.3
Atmospheric loss, dB	-0.2	-0.2
Downlink rain loss, dB	0.0	-3.4
Rain temp increase, dB	0.0	-2.6
Rcv. antenna pointing loss, dB	-0.5	-0.5
Ground G/T, dB/K	20.2	20.2
Bandwidth, dB-Hz	74.8	74.8
Boltzmann's constant, dBW/Hz K	228.6	228.6
	16.5	**10.4**
	Clear Sky	**Rain Dn**
Uplink C/N (thermal), dB	26.3	26.3
Downlink C/N (thermal), dB	16.5	10.4
x-pol interference, dB	99.0	99.0
C/I from ASI	15.1	15.1
Total C/(N+I), dB	**12.6**	**9.1**
Required C/(N+I), dB	**3.0**	**3.0**
Margin, dB	**9.6**	**6.1**

APPENDIX B

17 GHz TRANSMIT ANTENNA FAR OFF-AXIS PREDICTED AND MEASURED GAIN PERFORMANCE

Pursuant to Section 25.264(a) and (c) of the Commission's rules and the *17/24 GHz BSS Second R&O*,[9] DIRECTV Enterprises, LLC ("DIRECTV") hereby submits the predicted and measured transmitting antenna off-axis gain information for DIRECTV RB-79W, a geostationary satellite in the 17/24 GHz Broadcasting Satellite Service (BSS) to be operated at the nominal 79° W.L. orbital location. The predicted information must be submitted in applications for new 17/24 GHz BSS authorization, and the measured performance is to be submitted nine months prior to launch.[10]

Section 25.264(a) requires submission of predicted transmitting antenna off-axis antenna gain information:

(1) in the X-Z plane, *i.e.*, the plane of the geostationary orbit, over a range of ±30 degrees from the positive and negative X axes in increments of 5 degrees or less;

(2) in planes rotated from the X-Z plane about the Z axis, over a range of ±60 degrees relative to the equatorial plane, in increments of 10 degrees or less;

(3) in both polarizations;

(4) at a minimum of three measurement frequencies determined with respect to the entire portion of the 17.3-17.8 GHz frequency band over which the space station is designed to transmit: 5 MHz above the lower edge of the band; at the band center frequency; and 5 MHz below the upper edge of the band; and

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9 *Establishment of Policies and Service Rules for the Broadcasting-Satellite Service at the 17.3-17.7 GHz Frequency Band and at the 17.7-17.8 GHz Frequency Band Internationally, and at the 24.75-25.25 GHz Frequency Band for Fixed Satellite Services Providing Feeder Links to the Broadcasting-Satellite Service and for the Satellite Services Operating Bi-directionally in the 17.3-17.8 GHz Frequency Band*, 26 FCC Rcd. 8927 (2011) ("*17/24 GHz BSS Second R&O*").

10 The spacecraft carrying the DIRECTV RB-79W payload is already fully constructed and scheduled to be launched on May 20, 2015. Accordingly, DIRECTV is submitting with this application a request for waiver of this requirement to the extent necessary to accommodate the timing of this showing.

(5) over a greater angular measurement range, if necessary, to account for any planned spacecraft orientation bias or change in operating orientation relative to the reference coordinate system. The applicant must also explain its reasons for doing so.

Section 25.264(c) requires submission of measured transmitting antenna off-axis antenna gain information over the same angular ranges and frequencies as specified in 25.264(a).

In the Technical Attachment included with this Appendix, DIRECTV submits both the predicted and measured performance data for DIRECTV RB-79W.[11] This data was obtained by the satellite manufacturer, Orbital ATK, and covers the range of off-axis angles and frequencies called out in the rule. The measured performance was generated using the actual measured performance of the transmit feed, the known characteristics of the actual transmit antenna, and the known characteristics of the east side spacecraft panel as inputs to a detailed scattering analysis to generate measured far off-axis performance results. The predicted and measured performance results are shown side-by-side in the Technical Attachment and good agreement between the two sets of results can be seen throughout.

DIRECTV notes that measured data is to be collected under conditions as close to flight configuration as possible, though the Commission has specifically recognized that this exercise may be conducted with "the use of simulated spacecraft components." DIRECTV now has experience with multiple spacecraft manufacturers, all of whom maintain that, at the far off-axis angles specified in Section 25.264, the antenna feed itself is the main contributor to radiation. The fact that the initially predicted performance agrees so well with the measured performance generated through use of feed measurements and a detailed scattering analysis supports this contention.

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[11] Since DIRECTV does not plan any orientation bias or change in operating orientation relative to the reference coordinate system for this spacecraft, it has provided predictions only over the range called for in the rule. *See* 47 C.F.R. § 25.264(a)(5).

In addition to the above, Section 25.264(d) provides that, no later than nine months prior to launch, a 17/24 GHz BSS licensee must provide PFD calculations based upon the measured transmitting antenna off-axis gain information. As demonstrated in Table 1 below, based on the measured data, the satellite will not exceed the -117 dBW/m^2/100 kHz PFD coordination trigger with respect to any DBS satellite located more than 0.15° away. Since the requested orbital location of DIRECTV RB-79W is 78.8° W.L. and the nearest prior-filed or subsequently-filed DBS space station is QUETZSAT-1, located at 77° W.L. (*i.e.*, 1.8° away), the spacecraft will not trigger the PFD threshold at any relevant location.

Max power into antenna (dBW/36 MHz)	15.24
Max power density into antenna (dBW/100 kHz)	-10.32
Max off-axis measured antenna gain (dBi)	3.80
Max off-axis EIRP density (dBW/100 kHz)	-6.52
Coordination trigger value (dBW/m^2/100 kHz)	-117
Req'd spreading loss to meet coord trigger (dB-m^2)	110.47
Req'd distance to achieve spreading loss (km)	94.17
Geocentric orbital separation equal to 94.17 km (deg)	0.15

Table 1. Orbital Separation Required to Meet Coordination Trigger

TECHNICAL ATTACHMENT

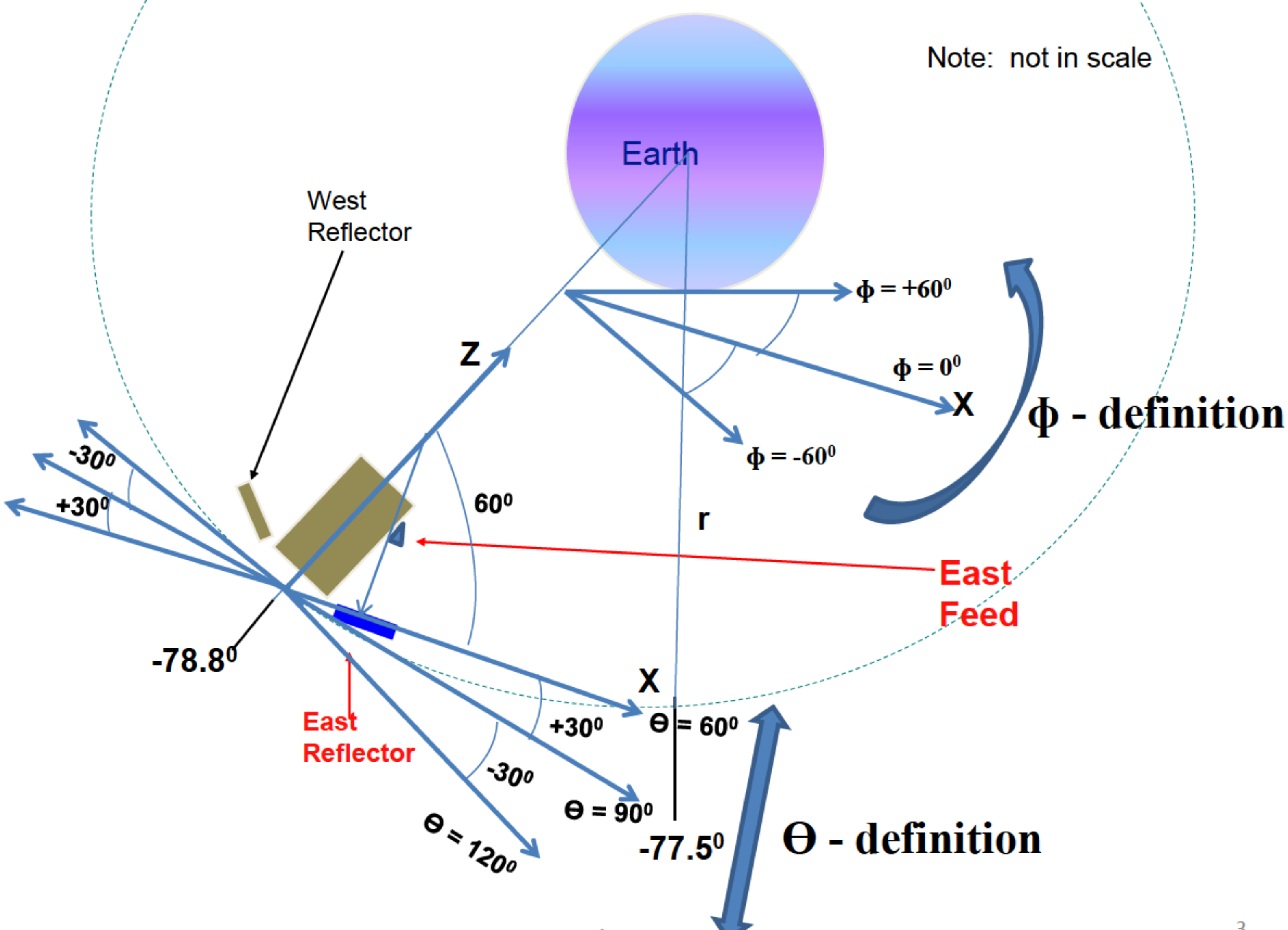
SKYM-1 R-Band Off-Axis Performance Report

March 24, 2015

RDBS Max Broadside Requirement

- **Required Angular Ranges for Antenna Off-Axis Gain Data"**
  - Transmitting antenna off-axis gain over a range of ±30º from the X axis in the X-Z plane (in 5° intervals), and over a range of ±60º in planes rotated about the Z axis (in 10° intervals).
  - Off-axis antenna gain measurements be made at a minimum of three frequencies (5 MHz above the lower edge of the band; at the band center frequency; and 5 MHz below the upper edge of the band).
- **Two-Part Submission Process for Antenna Off-Axis Gain Data"**
  - Submit predicted transmitting antenna off-axis gain information over the angular ranges described above. Provide pfd calculations on the basis of this predicted antenna gain data.
  - Confirm the predicted data by submitting measured off-axis antenna gain information over the same angular ranges described above.
  - To the extent practical, measurements should be made under conditions as close to flight configuration as possible. This could be done with the antenna mounted on the spacecraft or may include the use of simulated spacecraft components.

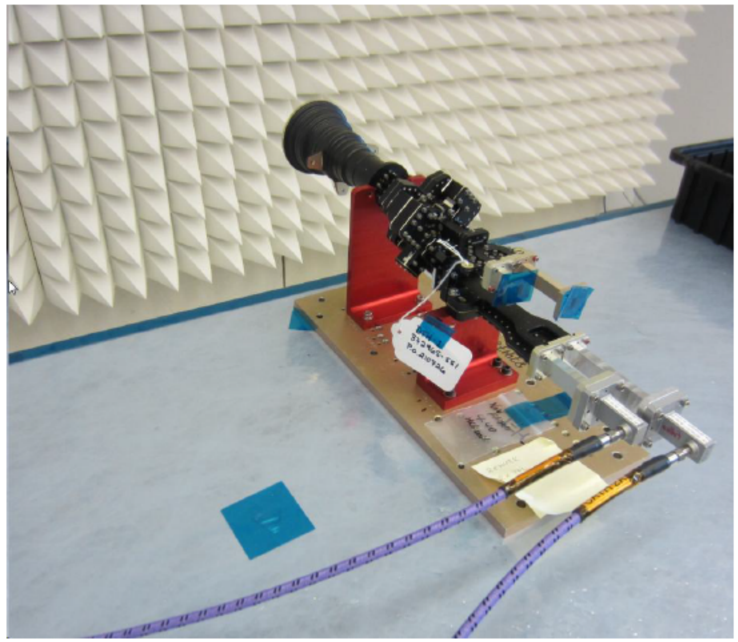
Θ and ϕ - Definition in Spacecraft Coordinates



R band Feed Assembly Test Summary

- R band feed assembly test took place in MDA Facility in June/July 2014.
- RF test conducted per following procedure
  - MDA - RF Test Procedure, doc no: 873103
- Patterns were measured for following polarizations and frequencies.
  - LHCP: 17305 MHz, 17550 MHz and 17775 MHz
  - RHCP: 17305 MHz, 17550 MHz and 17775 MHz

R Band feed assembly during radiation pattern measurement at MDA



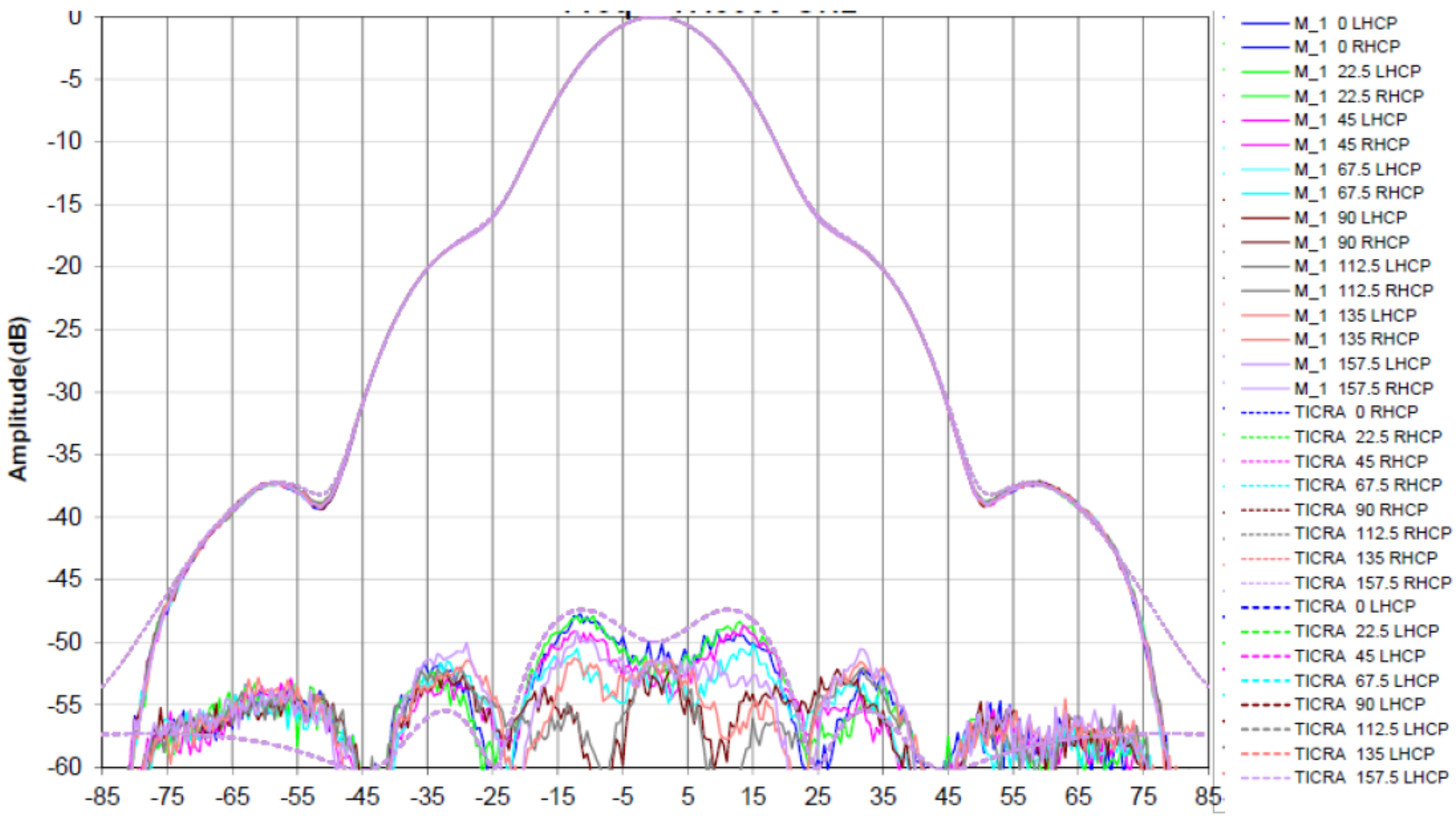
R Band feed assembly during RF functional measurement at MDA

Representative Plot: Measured and Predicted Radiation Patterns

DIRECTV

Orbital ATK

- Test Frequency and polarization: 17.305 GHz LHCP
- Predict and test radiation pattern overlay is presented.



Solid Cuts –Measurement

Dotted Cuts – Predict

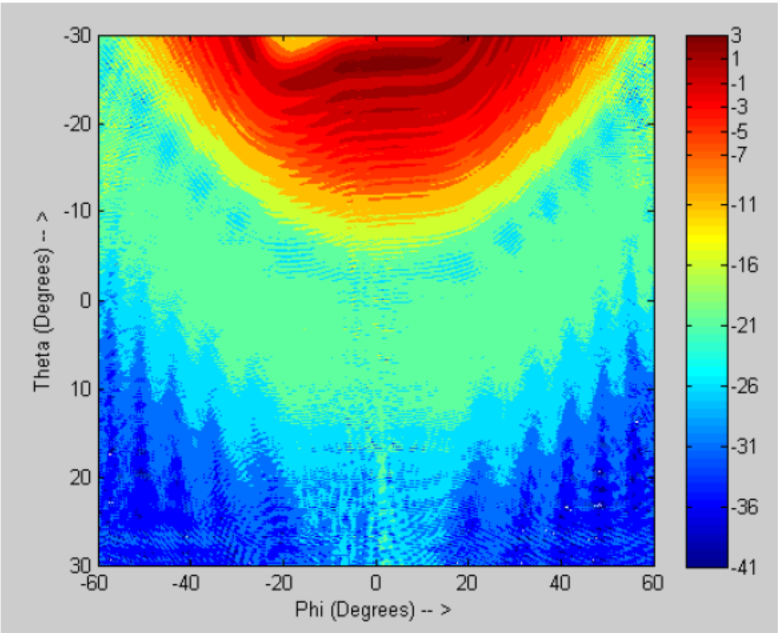
R Band Off-Axis Scattering Performance Analysis

- East Antenna scattering analysis was performed using feeds, as-built reflector and east side spacecraft panel as shown in Appendix A.
- R band transmit off-axis scattering performance was analyzed using two sets of feed radiation patterns.
  - Predict: As-designed feed radiation patterns predicted during CDR were used to generate antenna far-field patterns. Scattering performance was calculated using these antenna far-field patterns.
  - Measurement: Final measured feed radiation patterns from MDA were used to generate antenna far-field patterns. Scattering performance was calculated using these antenna far-field patterns.
- Performance was analyzed for ±30º from the X axis and –X axis in the X-Z plane and over a range of ±60º in planes rotated about the Z axis.
- Scattering performance was analyzed based on scattering components as presented in Appendix.
- Scattering performance plots for both predicted and measured feed patterns were generated and compared side by side.

East R-Band Antenna: Off-axis Scattering Performance Results in +X direction

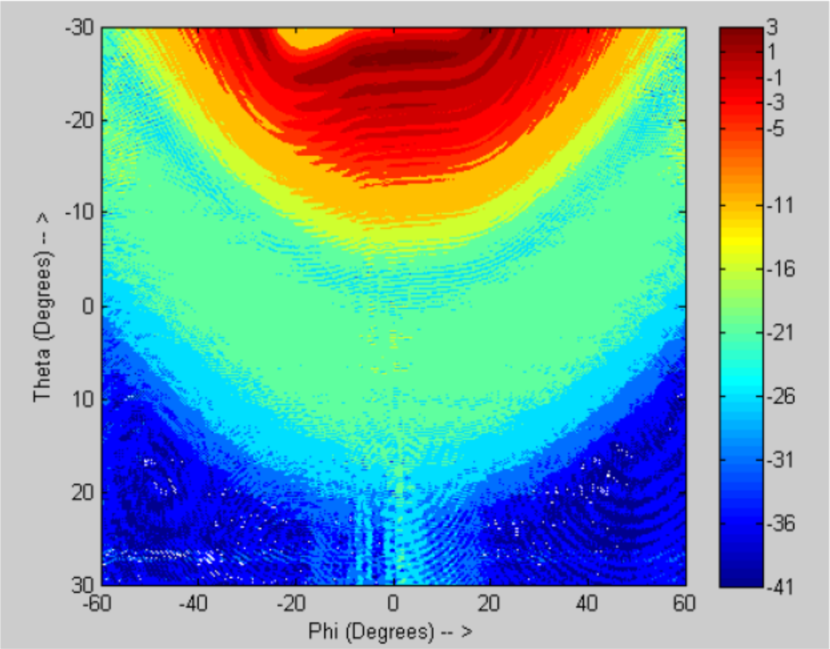
Scattering Performance Comparison: Predict and Measurement Plots - LHCP 17305 MHz

Predict



Peak = 2.9 dB
CF = 15.09 dBW

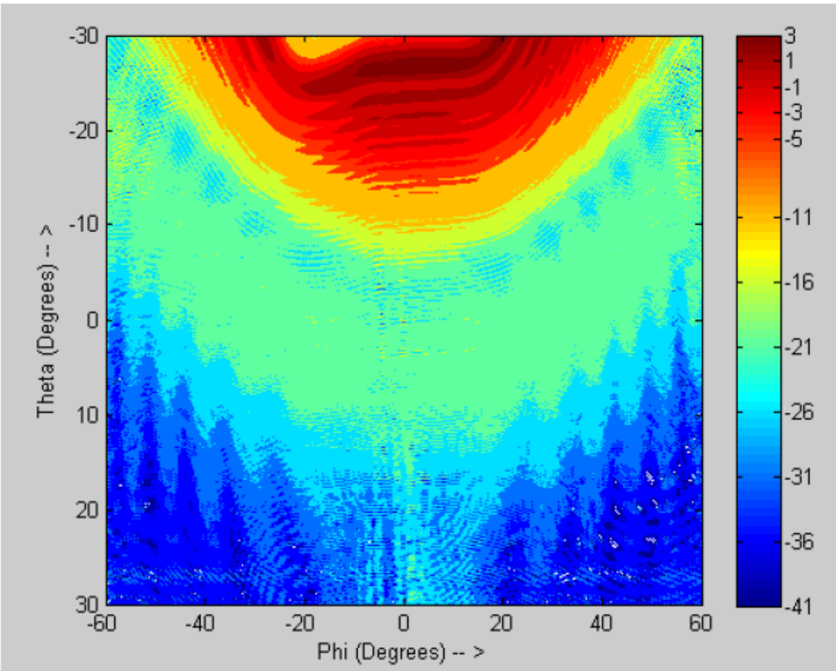
Measurement



Peak = 3.6dB
CF = 15.09 dBW

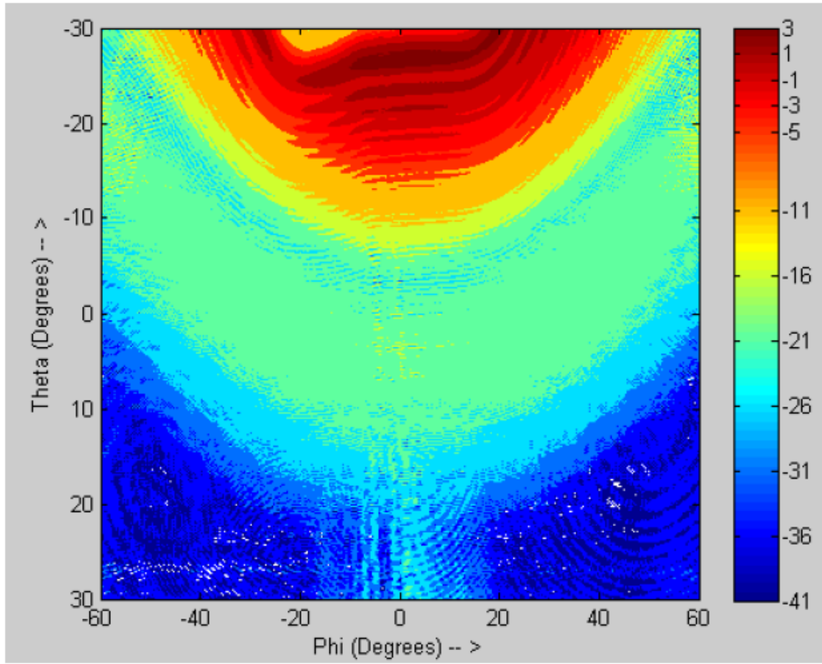
Scattering Performance Comparison: Predict and Measurement Plots - LHCP 17550 MHz

Predict



Peak = 3. 1 dB
CF = 15.07 dBW

Measurement

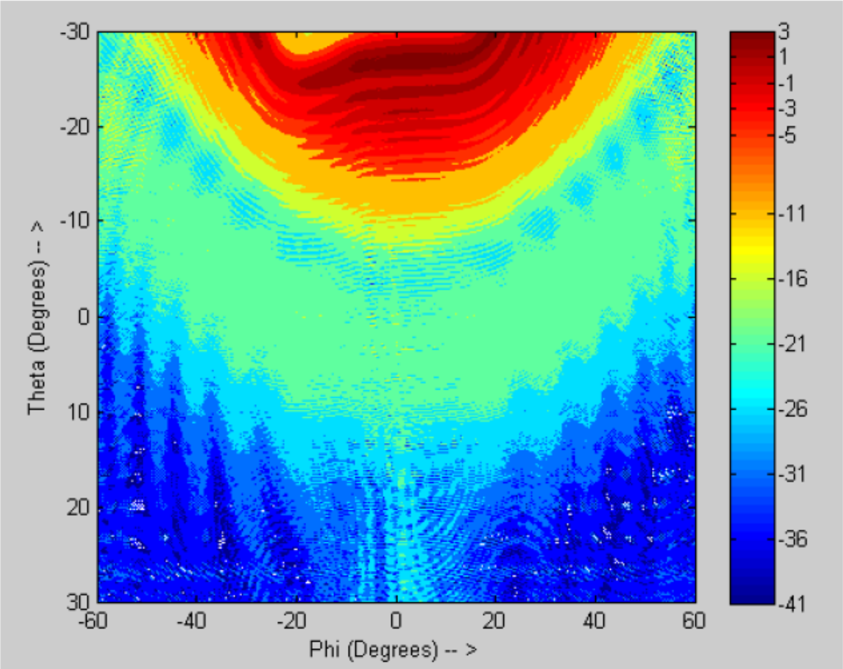


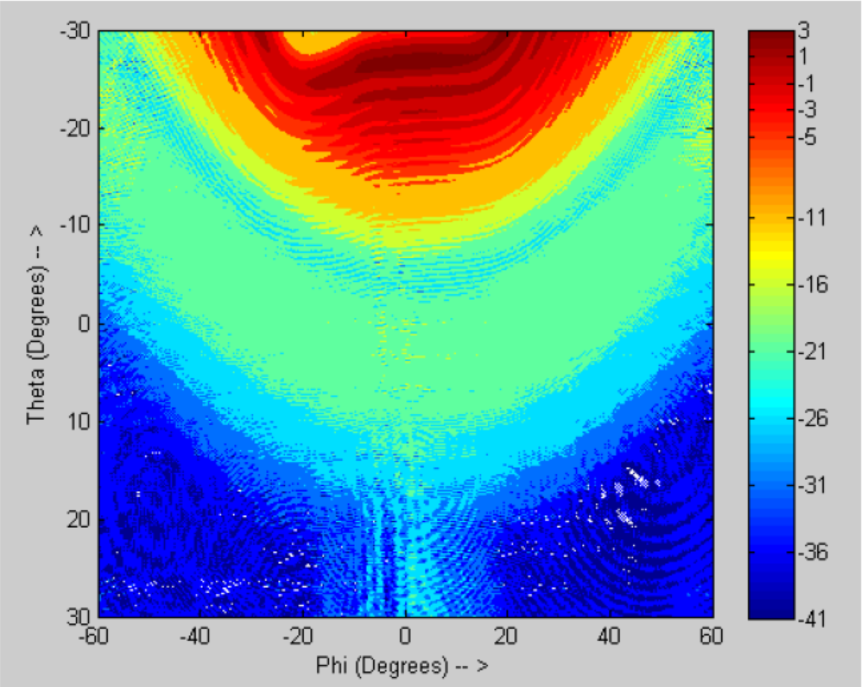
Peak = 3.7dB
CF = 15.07 dBW

Scattering Performance Comparison: Predict and Measurement Plots - LHCP 17795 MHz

Predict

Measurement



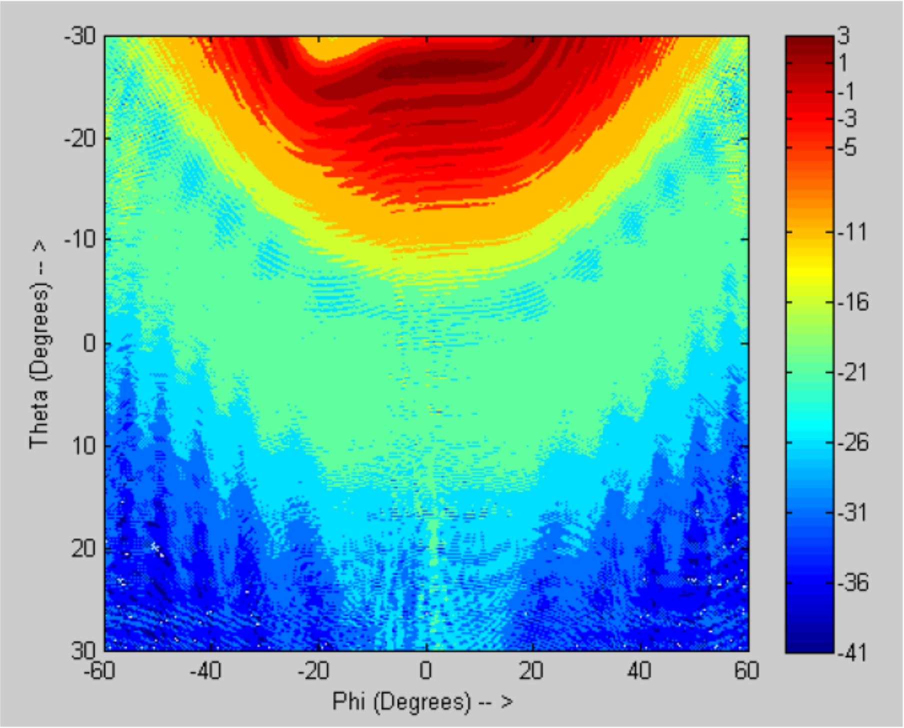


Peak = 3. 1 dB
CF = 15.07 dBW

Peak = 3.6dB
CF = 15.07 dBW

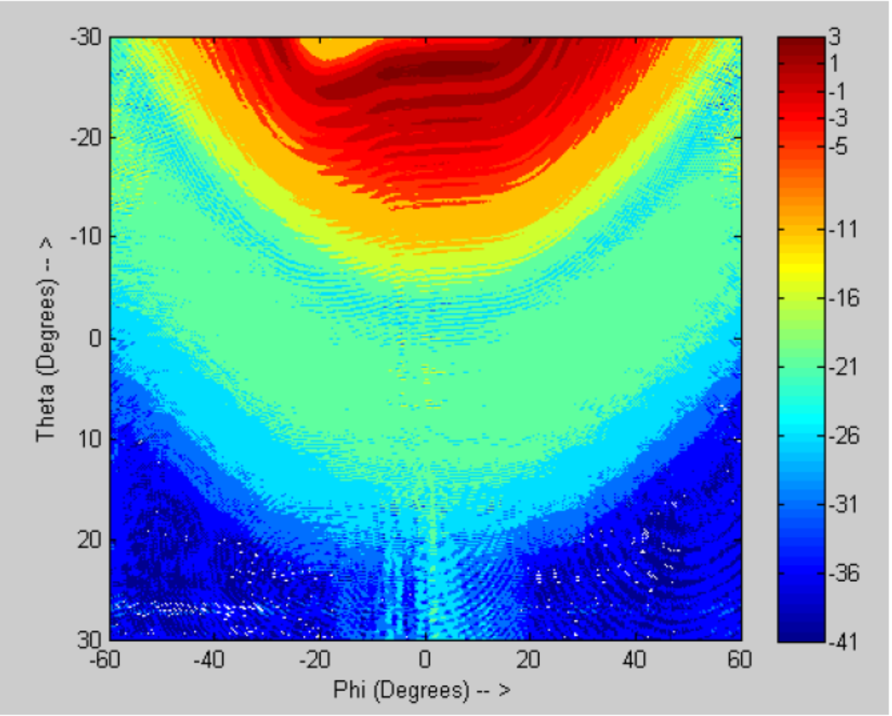
Scattering Performance Comparison: Predict and Measurement Plots - RHCP 17305 MHz

Predict



Peak = 2.9dB
CF = 15.15 dBW

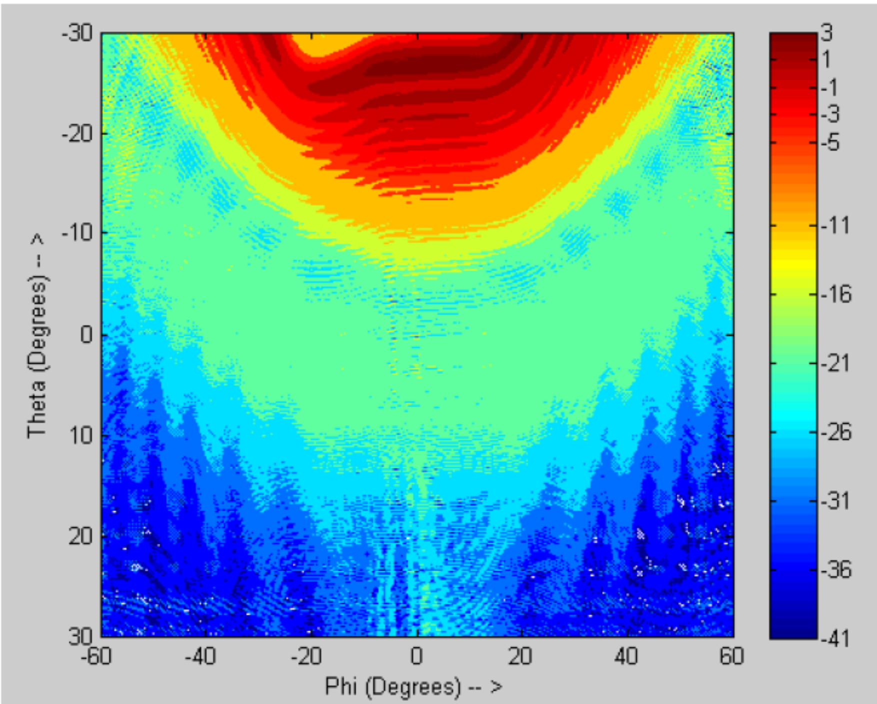
Measurement



Peak = 3.7 dB
CF = 15.15 dBW

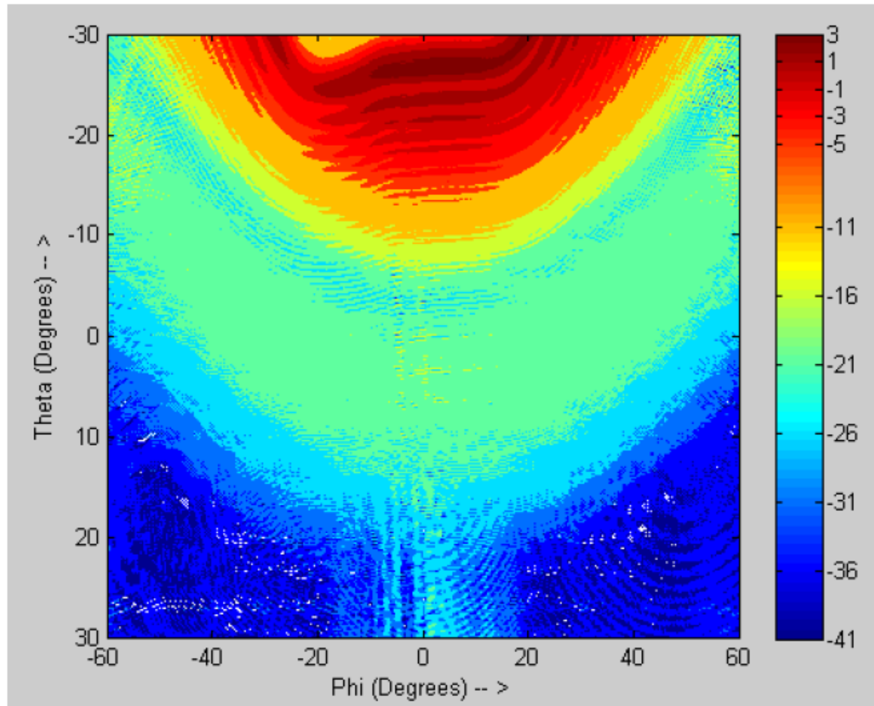
Scattering Performance Comparison: Predict and Measurement Plots - RHCP 17550 MHz

Predict



Peak = 3. 1 dB
CF = 15.26 dBW

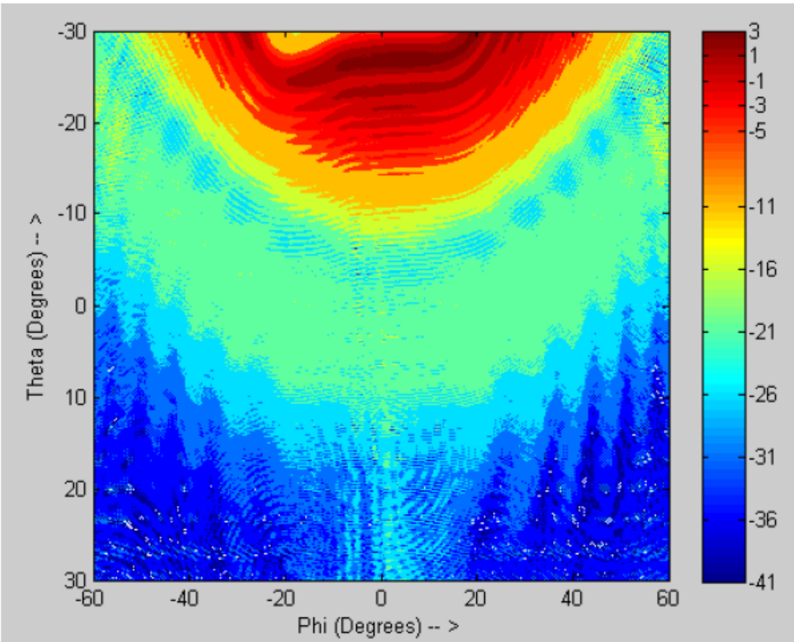
Measurement



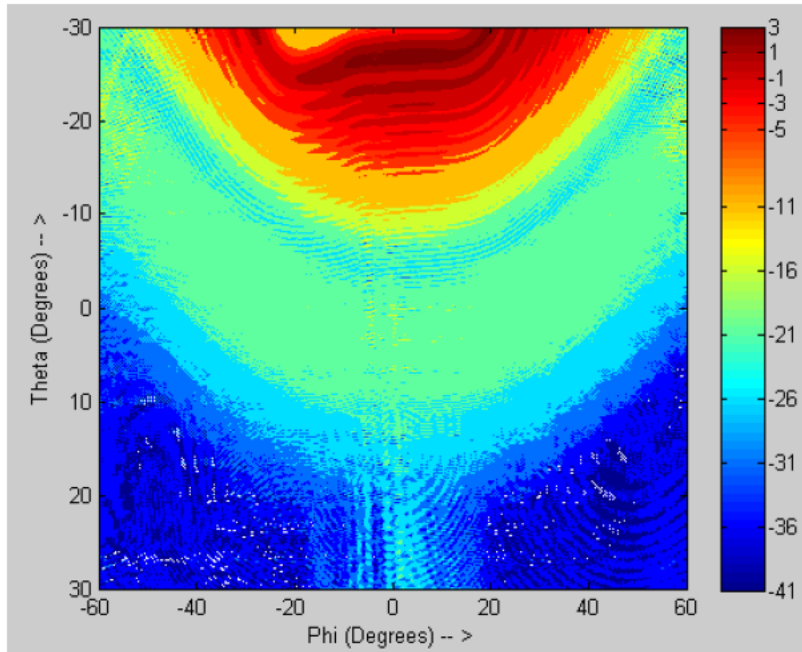
Peak = 3.8dB
CF = 15.26 dBW

Scattering Performance Comparison: Predict and Measurement Plots - RHCP 17795 MHz

Predict



Measurement



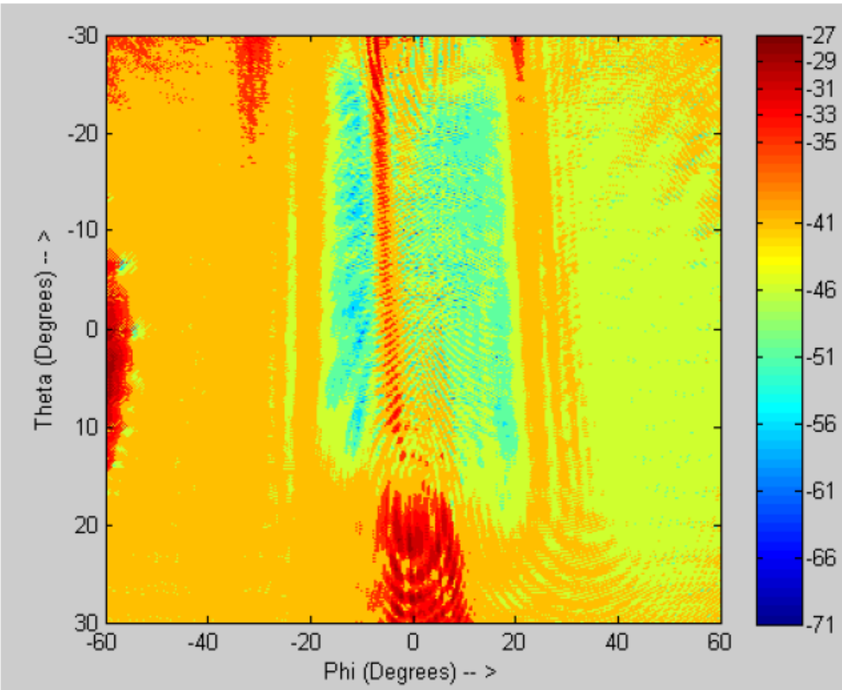
Peak = 3. 1 dB
CF = 15.24 dBW

Peak = 3.8dB
CF = 15.24 dBW

East R-Band Antenna: Off-axis Scattering Performance Results in -X direction

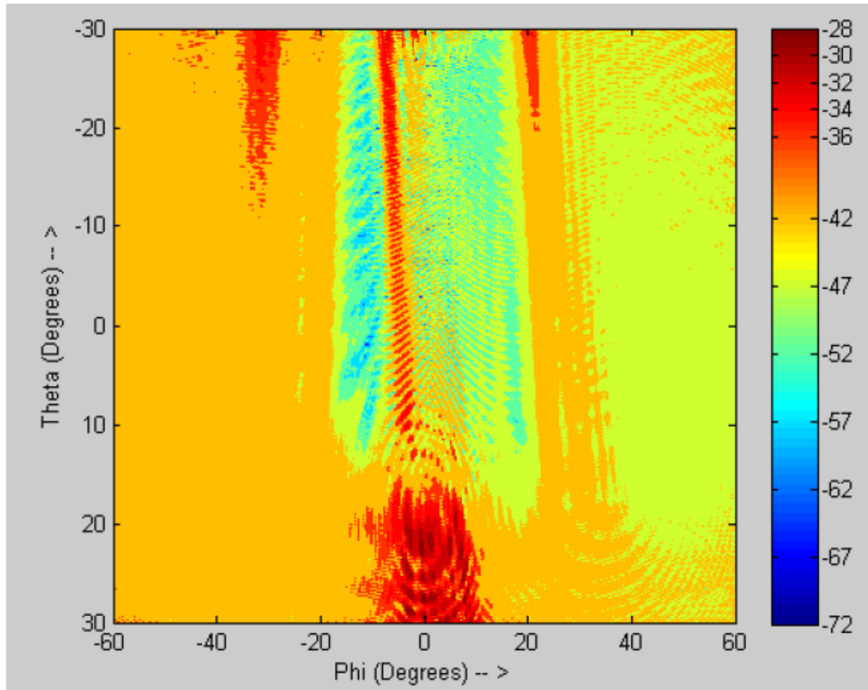
Scattering Performance Comparison: Predict and Measurement Plots - LHCP 17305 MHz

Predict



Peak = -27.2 dB
CF = 15.09 dBW

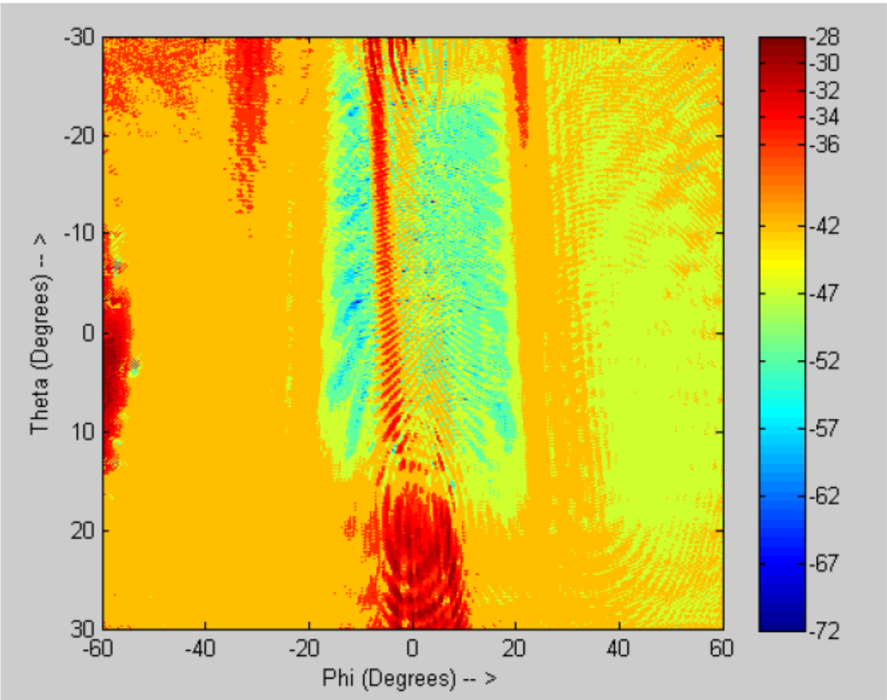
Measurement



Peak = -28.2dB
CF = 15.09 dBW

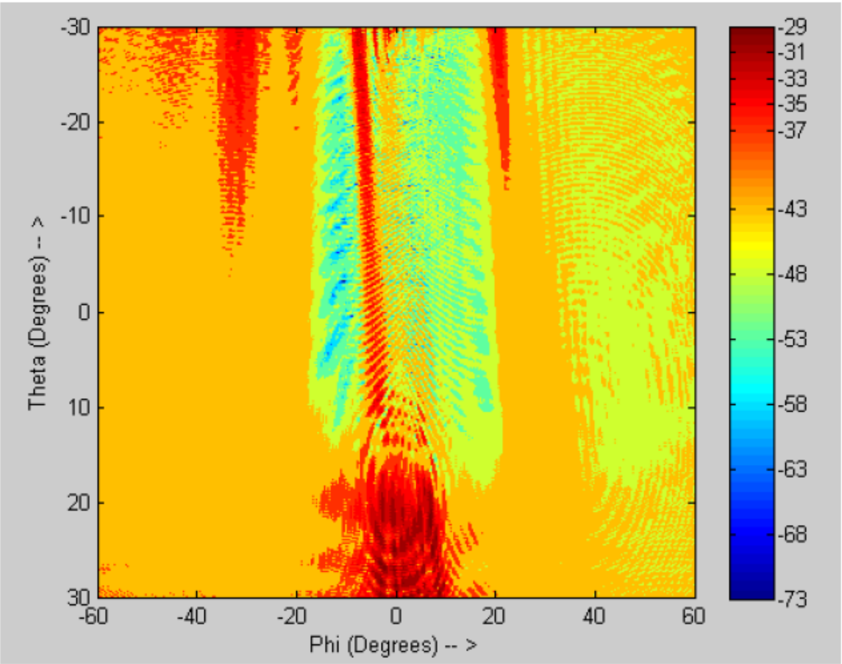
Scattering Performance Comparison: Predict and Measurement Plots - LHCP 17550 MHz

Predict



Peak = -27.8 dB
CF = 15.07 dBW

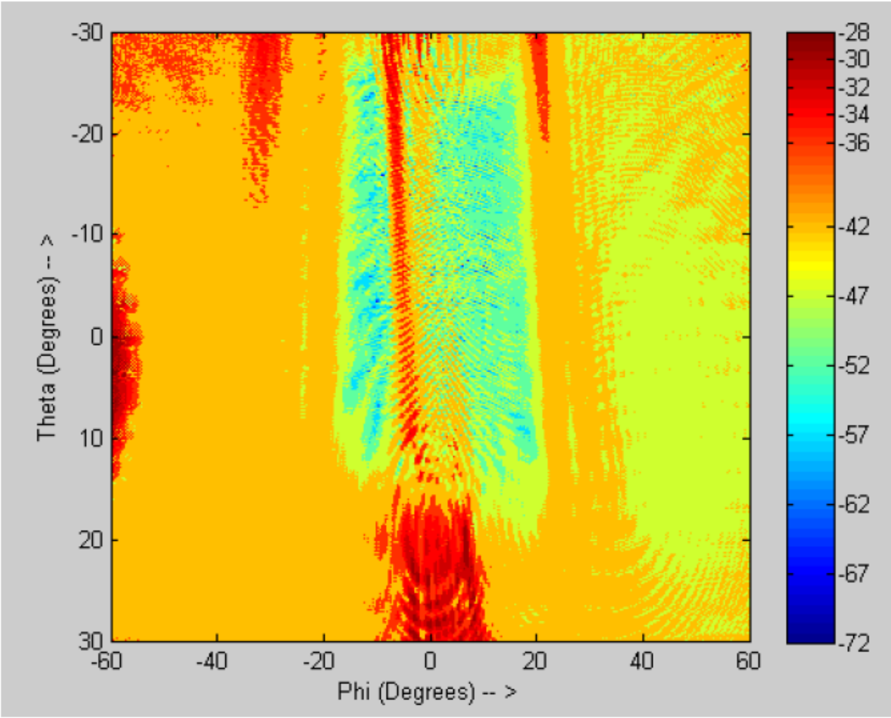
Measurement



Peak = -28.5dB
CF = 15.07 dBW

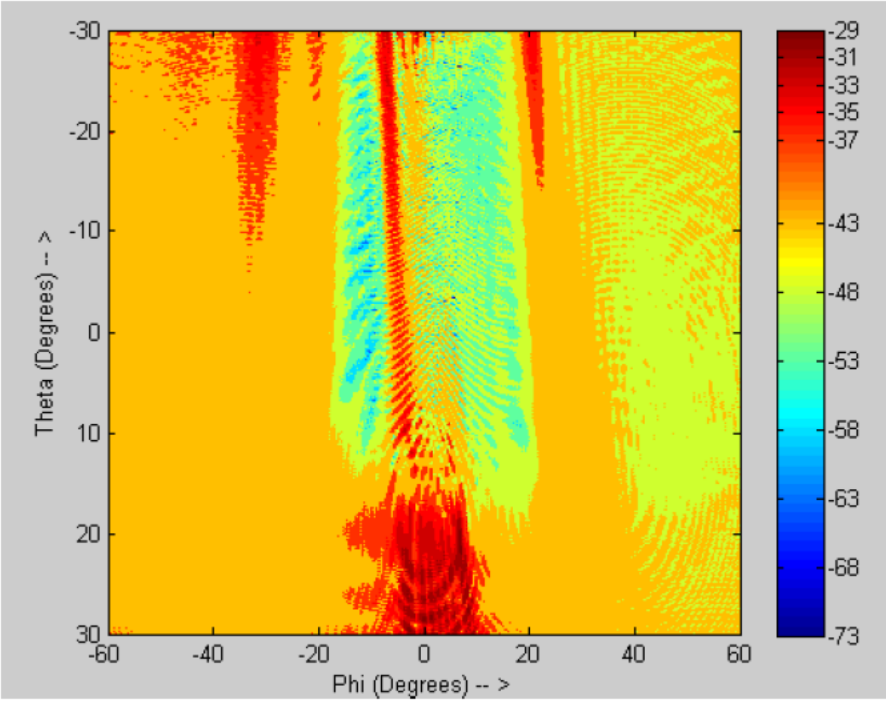
Scattering Performance Comparison: Predict and Measurement Plots - LHCP 17795 MHz

Predict



Peak = -27.8 dB
CF = 15.07 dBW

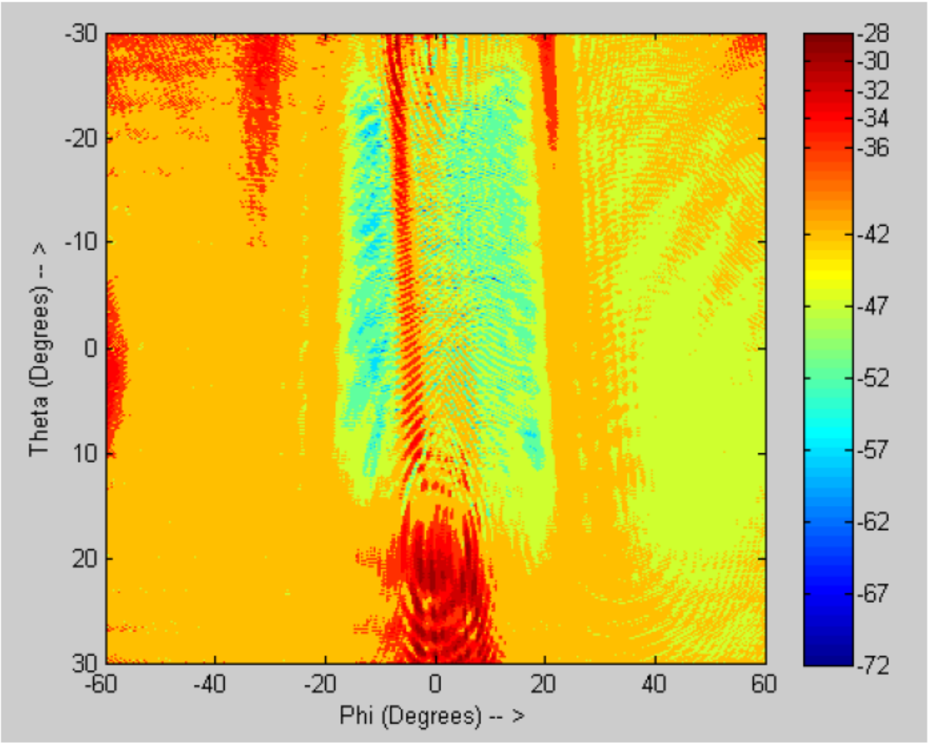
Measurement



Peak = -28.9 dB
CF = 15.07 dBW

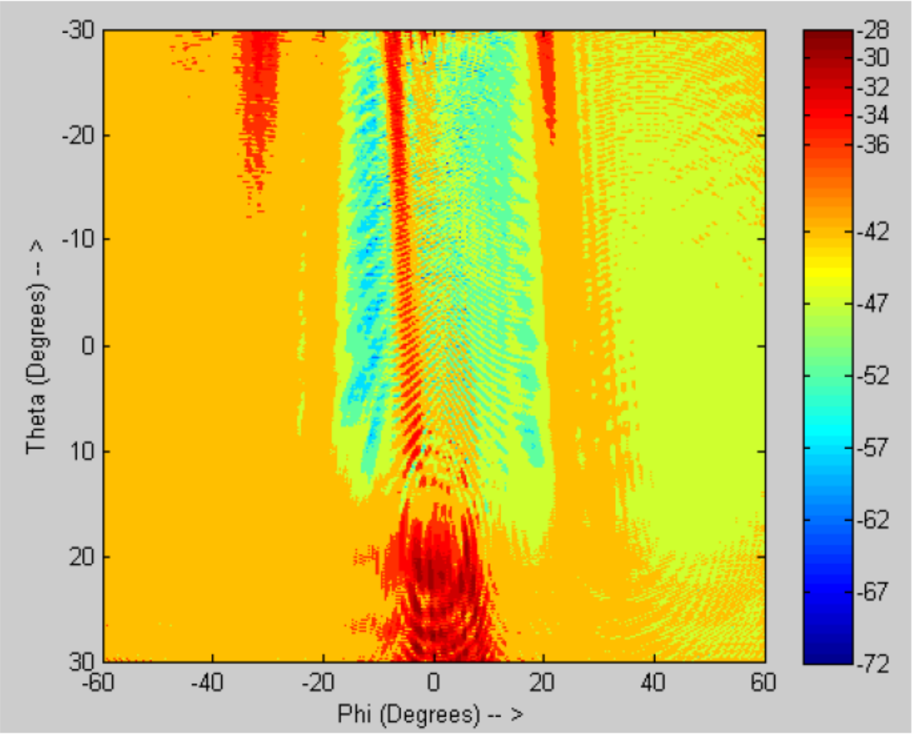
Scattering Performance Comparison: Predict and Measurement Plots - RHCP 17305 MHz

Predict



Peak = -28.2dB
CF = 15.15 dBW

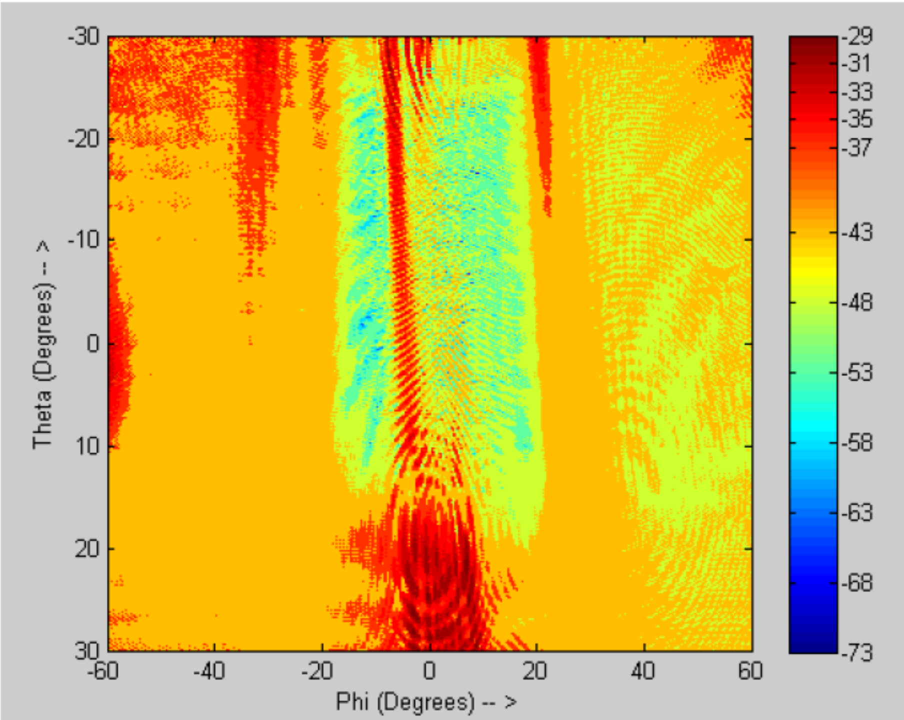
Measurement



Peak = -28.2 dB
CF = 15.15 dBW

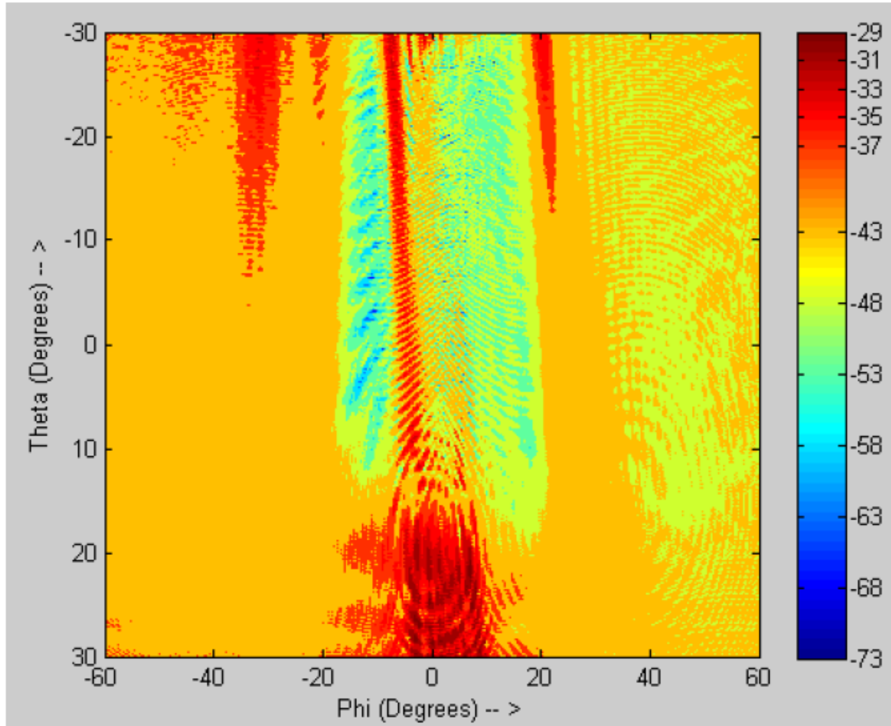
Scattering Performance Comparison: Predict and Measurement Plots - RHCP 17550 MHz

Predict



Peak = -28.6 dB
CF = 15.26 dBW

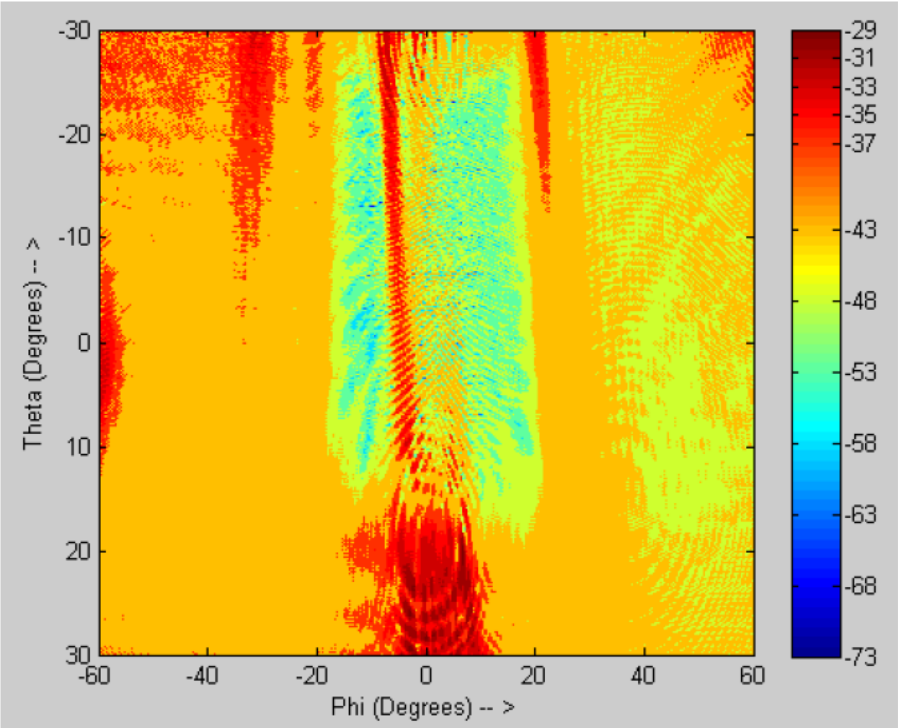
Measurement



Peak = -28.7dB
CF = 15.26 dBW

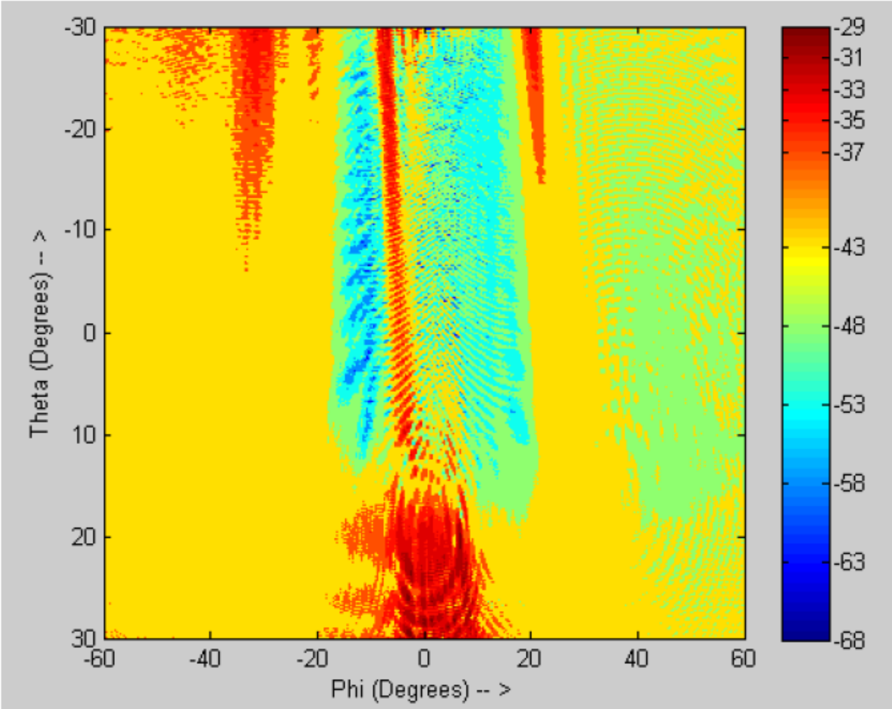
Scattering Performance Comparison: Predict and Measurement Plots - RHCP 17795 MHz

Predict



Peak = -29.0dB
CF = 15.24 dBW

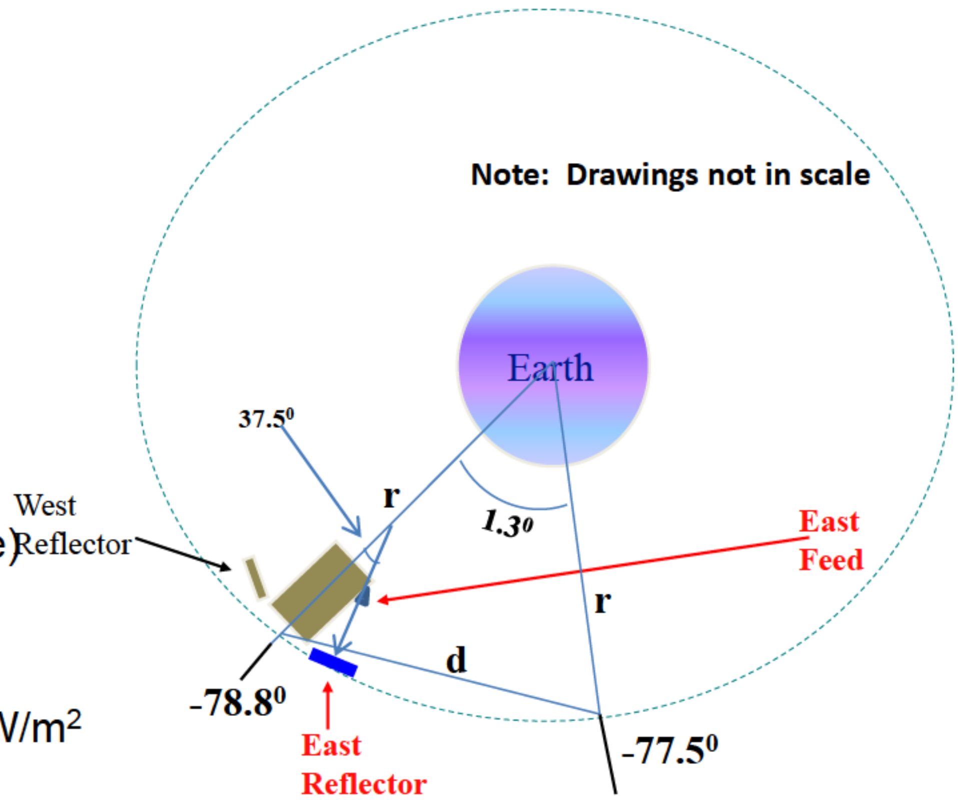
Measurement



Peak = -28.7 dB
CF = 15.24 dBW

Worst Case - Off-axis Power Flux Density @ RHCP 17795 MHz in +X Direction

- Worst Case Orbital Location = -78.8^0
- Angular Separation = 1.3^0
- r = (6378 + 35,786) km = 42164 km
- Distance between orbital location
  - $d^2 = r^2 + r^2 - 2*r*r*\cos(1.3*pi/180)$
  - d = 956650.3 m
- Spreading Loss: $Loss = 10\log\left(\frac{1}{4\Pi d^2}\right)$
  - Loss = 130.6 dB/m^2
- Peak radiation Level over all ±60^0 and ±30^0
  - 3.8 dBi (Predict peak from Previous page)
- Conversion Factor = 15.24 dBW
- Peak EIRP Level = 3.8+15.24= 19.0 dBW
- Peak PFD = 19.0 -130.6 dBW/m^2 = -111.6 dBW/m^2
- For 100 KHz, PFD = -111.6 – 10*log(30X10^6 / 100X10^3) dBW/m^2 /100 KHz
- Peak PFD = -111.6- 24.7 dBW/m^2 /100 KHz
- **Peak PFD = -136.3 dBW/m^2 /100 KHz**
- **Spec Requirement is -117 dBW/m^2 /100 KHz**
- **Margin = 19.3 dB**



Conclusion

- PFD Performance is compliant over region ±30º from X axis and -X axis in the X-Z plane and over a range of ±60º in planes rotated about the Z axis.
- Scattering analysis shows that change in PDF performance analyzed using predicted feed patterns and measured feed patterns is very small.

Appendix

East Antenna Scattering Analysis

- Analysis was performed using following scattering components.

1: Feeds -> Reflector -> FF
2: Feeds -> FF
3: Feed -> Panel -> Reflector -> FF
4: Feed -> Reflector -> Panel -> FF