SheppardMullin

Sheppard, Mullin, Richter & Hampton LLP
2099 Pennsylvania Avenue, NW, Suite 100
Washington, D.C. 20006-6801
202.747.1900 main
202.747.1901 fax
www.sheppardmullin.com

Brian D. Weimer
202.747.1930 direct
bweimer@sheppardmullin.com

September 10, 2017

File Number: 48HH-246229

VIA ECFS & IBFS

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street S.W.
Washington, D.C. 20554

Re: **Notice of Ex Parte Presentation in IB Docket No. 16-408**

Petition for Declaratory Ruling of LeoSat MA, Inc., IBFS File No. SAT-PDR-20161115-00112
Amendment to Application of O3b Limited, IBFS File No. SAT-AMD-20161115-00116
Application of Space Exploration Holdings, LLC, IBFS File No. SAT-LOA-20161115-00118
Petition for Declaratory Ruling of ViaSat, Inc., IBFS File No. SAT-PDR-20161115-00120
Application of Theia Holdings A, Inc., IBFS File No. SAT-LOA-20161115-00121
Petition for Declaratory Ruling of Kepler Communications, Inc., IBFS File No. SAT-PDR-20161115-00114

Dear Ms. Dortch:

On September 7, 2017, representatives of WorldVu Satellites Limited ("OneWeb") met with members of the Satellite Division of the Commission's International Bureau to discuss the ongoing rulemaking concerning Non-geostationary ("NGSO"), Fixed-Satellite Service ("FSS") Systems. A list of the meeting attendees is attached as Exhibit 1.

In particular, the parties discussed the critical importance of compliance with equivalent power flux density ("EPFD") limits established by the International Telecommunications Union ("ITU") for NGSO constellations seeking U.S.-licensing or U.S. market access. As a threshold matter, OneWeb notes that Section 25.146(a) of the Commission's rules requires the Commission to return as unacceptable for filing non-compliant EPFD technical demonstrations in the Ku-band.[1]

[1] *See* 47 C.F.R. § 25.146(a) ("If the technical demonstration exceeds the validation EPFD limits at any test points within the U.S. for domestic service and at any points outside of the U.S. for international service or at any points in the geostationary satellite orbit, as appropriate, the

OneWeb has expended considerable resources ensuring its system operates in full compliance with the ITU's Article 22 EPFD limits and expects that other NGSO applicants will ensure this important element of their system design complies with applicable ITU and Commission regulations related to EPFD levels. While OneWeb previously provided some initial feedback on the EPFD showings of some applicants in the Commission's processing round for Ku-band and Ka-band NGSO FSS systems, due in part to the delays of other applicants' technical submissions, OneWeb noted that its analysis of this data remained ongoing and may need to be expanded upon in the future.[2]

The presentation attached herein contains an overview of the fundamental components of EPFD compliance as well as additional analyses of data provided by some NGSO FSS applicants, including data provided by one applicant very late in the comment cycle.[3] The data demonstrates clear non-compliance with EPFD requirements. OneWeb respectfully requests the Commission refrain from any action on these applications until interested parties have had further time to review the analyses contained in the attached presentation. Additionally, the Commission should request additional information from some applicants regarding the creation and validity of files submitted to demonstrate purported EPFD compliance.[4]

As noted in OneWeb's filings earlier this year, the Commission should adopt the ITU Article 22 EPFD limits applicable in the 17.8-18.6 GHz band across the same band in the U.S.[5] This will provide geostationary ("GSO") operators with adequate protection while providing additional operational flexibility for NGSO FSS operators. OneWeb also continues to believe the

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application would be unacceptable for filing and will be returned to the applicant with a brief statement identifying the non-compliance technical demonstration.").

[2] *See, e.g.,* Comments of WorldVu Satellites Limited, In re Space Exploration Holdings, LLC Application for Approval for Orbital Deployment and Operating Authority for the Space Exploration Holdings NGSO Satellite System, IBFS File No. SAT-LOA-20161115-00118, at 15 (filed June 26, 2017) ("OneWeb Comments"); Reply Comments of WorldVu Satellites Limited, In re Space Exploration Holdings, LLC Application for Approval for Orbital Deployment and Operating Authority for the Space Exploration Holdings NGSO Satellite System, IBFS File No. SAT-LOA-20161115-00118, at 2 (filed July 14, 2017) ("OneWeb Reply Comments").

[3] *See* Letter from William M. Wiltshire, Counsel to Space Exploration Holdings, to Marlene H. Dortch, IBFS File No. SAT-LOA-20161115- 00118 (July 12, 2017) (supplementing the pending application of Space Exploration Holdings with additional materials and corrections necessary to verify EPFD compliance).

[4] *See* 47 C.F.R. § 25.146(d) ("The Commission may request at any time additional information from the NGSO FSS system applicant or licensee concerning the EPFD levels and the related technical showings.").

[5] *See* OneWeb Comments at 22-24.

Commission should adopt the Article 22 EPFD limits in parallel with the provisions of Resolution 76 regarding aggregate EPFD levels.[6]

The importance of adherence to the well-established single-entry EPFD limits cannot be overstated. If one NGSO FSS system is allowed to exceed applicable single-entry EPFD limits, not only could service for GSO systems be negatively impacted, but the operations of other NGSO FSS systems may be unduly restricted and determining which individual operator is exceeding EPFD will be time consuming and burdensome. System design for EPFD compliance is one of the first steps an NGSO operator must undertake and it will be very hard to re-engineer into systems at a later date. The public will be harmed if systems are required to reduce their power levels and therefore reduce the broadband performance for consumers.

ITU Recommendation S.1503-2 constitutes the industry standard for calculation of EPFD statistics and it requires inputs to be consistent with actual NGSO system characteristics, both technical and operational. In order to generate meaningful and accurate outputs, valid inputs are required. These valid inputs include orbital characteristics, operational parameters, EIRP density masks, PFD masks, and other aspects that warrant close inspection in order to ensure the validity and consistency of EPFD calculations.

OneWeb has reviewed the EPFD validation showings of the applications and petitions filed pursuant to the Commission's Ku and Ka-band processing round to ensure the reported inputs are valid and representative, and that the systems will not exceed single-entry limits. Currently, there appear to be numerous inconsistencies between some applicants' technical narratives, the laws of physics, and the files they have submitted to the Commission for EPFD validation. These inconsistencies could result in multiple systems exceeding single-entry EPFD limits.

Contrary to the assertions of Space Exploration Holdings in its recent ex parte filing with the Commission, OneWeb's identification of these inconsistencies is not the result of "manipulat[ion] by a party willing to search out cases involving extreme geometries that are unlikely to occur, and then forcing the software to consider such cases, yielding exaggerated EPFD results," nor do they represent "pathological cases that are 'far too pessimistic' to meaningfully represent for NGSO systems with steerable beams."[7] As is shown in the attached presentation, Space Exploration Holdings' system design projects more than twice the allowed limit into GSO stationary antennas at nearly 60 degree elevation angles – a common elevation angle for a GSO stationary customer, and to locations like Louisiana which are directly within its proposed operational footprint. Space Explorations Holdings' failure to meet the EPFD requirements is

[6] *See* OneWeb Reply Comments at 6-8.

[7] Letter from William M. Wiltshire, Counsel to Space Exploration Holdings, to Marlene H. Dortch, IBFS File No. SAT-LOA-20161115-00118 (August 17, 2017) at 4, 10 ("SEH Letter").

rooted in the fact that their proposed NGSO system is a multi-altitude, multi-inclination constellation.[8]

The ITU and the Working Group have provided instructions on how to analyze the EPFD that will be generated by the Space Exploration Holdings NGSO system at its proposed, multiple operational altitudes. Although Space Exploration Holdings cites ITU Working Party 4A in support of its assertion that the ITU Recommendation S.1503-2 algorithm cannot adequately account for constellations that employ steerable beams, it fails to acknowledge that ITU Working Party 4A has clear instructions about how to use the ITU Recommendation S.1503-2 algorithm to determine the worst-case geometry for NGSO systems with different orbit characteristics.[9]

The ITU algorithm for selecting worst-case geometry – which Space Exploration Holdings relied on to demonstrate EPFD compliance at the FCC and ITU – requires multiple runs for each of the various inclinations, altitudes, and eccentricities such as those proposed for the Space Exploration Holdings NGSO FSS system. The Working Party clarified these rules in October 2016, noting that unless the software is used correctly it will output an incorrect Worst Case Geometry for such multi-altitude, multi-inclination, and/or multi-eccentricity systems. As Space Exploration Holdings failed to follow the Working Party guidelines for software usage, the assertion that it has "verified that all of its filed EPFD databases pass the FCC EPFD limits using ITU (Transfinite) algorithm for selecting worst-case geometry" is incorrect and provides cold comfort to not only the incumbent GSO operators who will be negatively impacted, but also other NGSO FSS systems who are raising and investing billions to fund the design and construction of their constellations.[10] Pursuant to any rules adopted in the above-referenced proceeding, prior to any grant of its pending license application, the Commission should require Space Exploration Holdings to demonstrate EPFD compliance at all points within the United States and its Territories and for all pointing directions towards the GSO arc, without neglecting any operational latitudes or inclinations.

Finally, the parties discussed issues related to orbital operations in a low-earth orbit environment that is likely to involve multiple constellations. OneWeb expressed its view that maintaining a minimum orbital separation between authorized constellations is necessary to facilitate accurate constellation mapping and a safe orbital environment. OneWeb asserted that the Commission should refrain from granting any applications or petitions that result in NGSO FSS systems operating at overlapping orbital altitudes.

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[8] Space Exploration Holdings, LLC, Application For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System, IBFS File No. SAT-LOA-20161115-00118 (Call Sign S2983) (filed Nov. 15, 2016), Technical Attachment at 1.

[9] Annex 21 to Working Party 4A Chairman's Report, Document 4A/TEMP/99 at Section 2.2.1.4.2.1 "Determination of Runs" (October 18, 2016).

[10] SEH Letter at 10.

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This submission and the attached presentation highlight OneWeb's substantial concerns with respect to the single-entry EPFD compliance and orbital safety issues presented by some NGSO FSS systems with pending license applications or U.S. market access petitions before the Commission. OneWeb respectfully requests the Commission refrain from acting on these applications until the concerns detailed herein are adequately resolved.

Pursuant to Section 1.1206(b) of the Commission's Rules, 47 C.F.R. § 1.1206(b), this letter is being filed via ECFS and IBFS and e-mailed to the meeting participants. Please do not hesitate to contact the undersigned with any questions.

Very truly yours,

/s/ Brian D. Weimer

Brian D. Weimer
for SHEPPARD, MULLIN, RICHTER & HAMPTON LLP

Attachments

cc: Jose Albuquerque
Chip Fleming
Diane Garfield
Joseph Hill
Christopher Bair
Merissa Velez
Cindy Speirs

SheppardMullin

Sheppard, Mullin, Richter & Hampton LLP
2099 Pennsylvania Avenue, NW, Suite 100
Washington, D.C. 20006-6801
202.747.1900 main
202.747.1901 fax
www.sheppardmullin.com

EXHIBIT 1

MEETING ATTENDEES

Representing the Commission

Jose Albuquerque
Chip Fleming
Diane Garfield
Joseph Hill
Christopher Bair
Merissa Velez
Cindy Speirs

Representing OneWeb

Brian Weimer
Greg Wyler
Mariah Shuman
Michael Lindsay
Marc Dupuis

OneWeb
ACCESS FOR EVERYONE

EPFD Validation

2017

EPFD Validation via Rec S.1503-2

- ITU Rec S.1503-2 provides an industry standard way of calculating EPFD statistics, but requires:
  - Inputs to be consistent with actual NGSO system characteristics, both technical and operational
  - Inputs to be properly created and valid according to Rec S.1503-2 guidelines

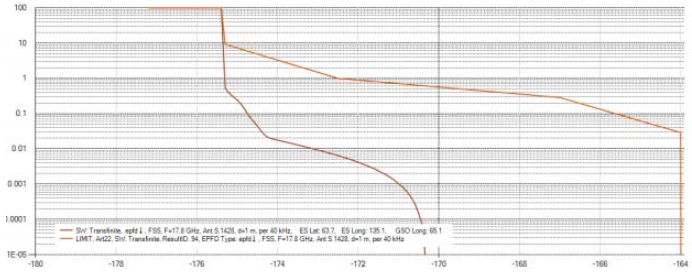
- It is important that operating NGSO systems adhere to the well-established single-entry limits in order for the aggregate limits not to be exceeded

- **<u>If a system is allowed to exceed single-entry EPFD limits:</u>**
  - **other NGSO systems may be overly-restricted**
  - **it may negatively impact service for GSO systems**

- Thus, OneWeb has reviewed applicants' EPFD validation showings to make sure inputs are valid and representative, and the systems will not exceed single-entry limits

Inputs to Rec S.1503-2 must be thoroughly vetted

- EPFD CDF plots are good indicators of compliance, but they represent only the output data



- Meaningful outputs require valid inputs which include:
  - Orbital characteristics, operational parameters, EIRP density masks, PFD masks, and other aspects that warrant close inspection in order to ensure validity and consistency
- Currently, there appear to be numerous inconsistencies between some applicants' technical narratives, physics, and the files they have submitted to the FCC for EPFD validation
- Some applicants have inputs that are not valid for proper use of Rec. S.1503-2

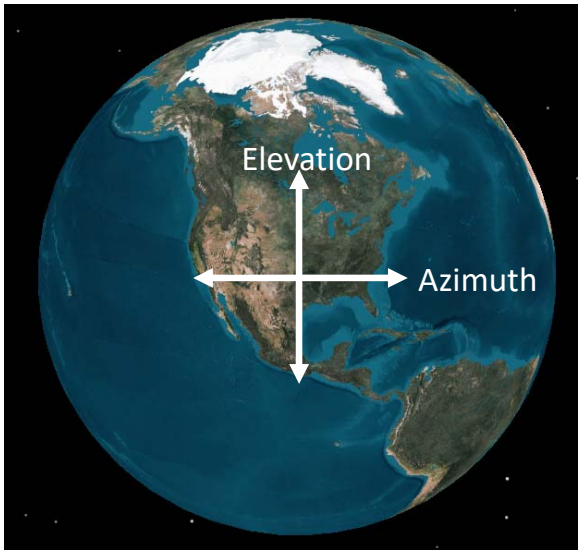
<u>These inconsistencies could result in multiple systems exceeding single-entry EPFD limits</u>

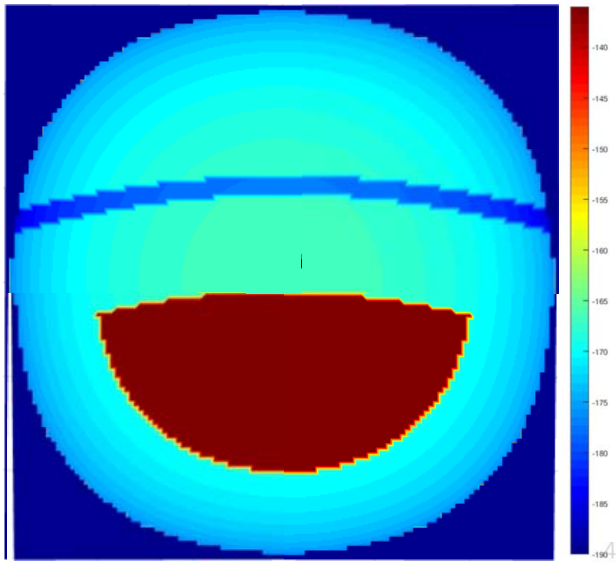
Key Input #1: PFD Mask

- The power flux-density (PFD) mask of the non-geostationary satellite system is defined as the maximum PFD generated by any space station in the system as seen from any point on the surface of the Earth
- Function of satellite latitude, satellite azimuth, and satellite elevation angles
- Formatted into large XML files that look like this:

```
<satellite_system sat_name="NGSO" ntc_id="1">
<pfd_mask mask_id="100" low_freq_mhz="10700" high_freq_mhz="12750" refbw_khz="40"
type="azimuth_elevation" a_name="latitude" b_name="azimuth" c_name="elevation">
  <by_a a="-80">
   <by_b b="-59">
    <pfd c="-59">-200</pfd>
    <pfd c="-58">-190</pfd>
    <pfd c="-57">-180</pfd>
    <pfd c="-56">-170</pfd>
    <pfd c="-55">-160</pfd>
        …
```

- Somewhat complicated, but data can be visually plotted as a function of NGSO satellite az/el angles

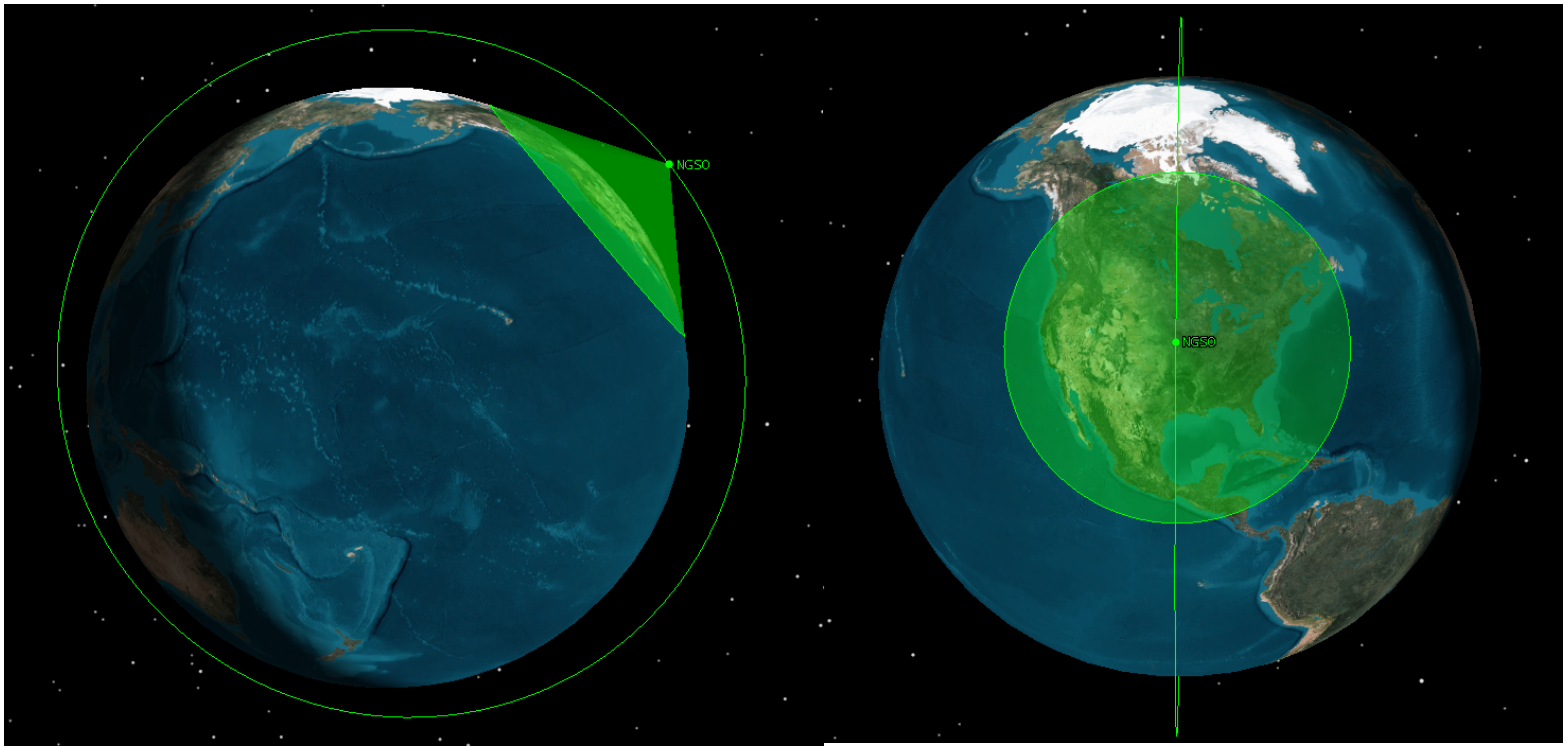




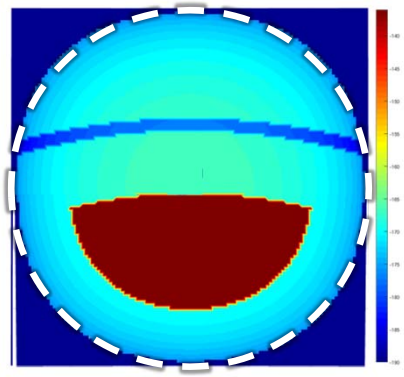
OneWeb

Visible Earth

Defined by orbital altitude

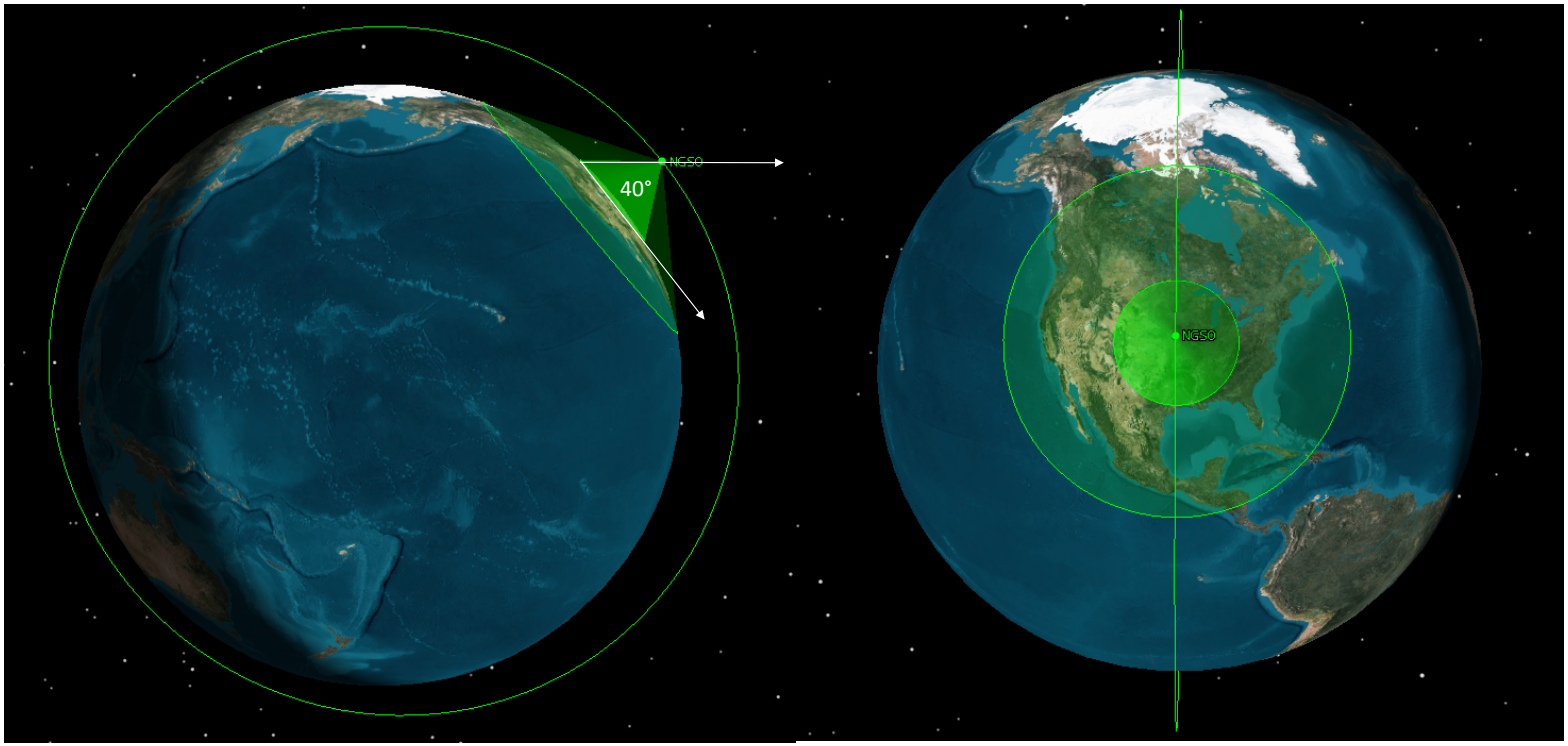


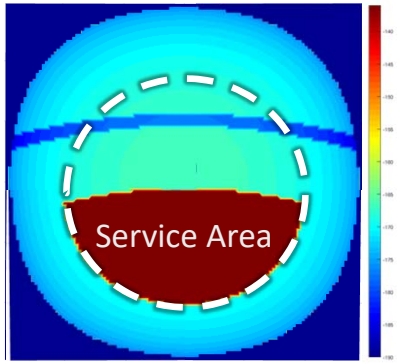
PFD values are required for every point within this circle



Service Area

Constrained by a user terminal minimum operating elevation angle



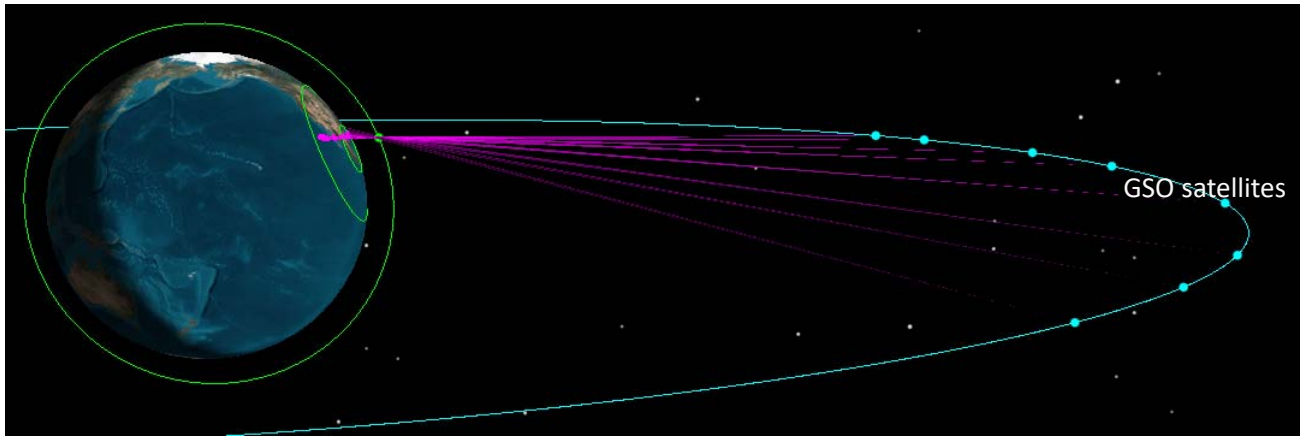


In this example, all users inside the service area will have elevation angles greater than 40°

PFD values within the service area will be greater than elsewhere

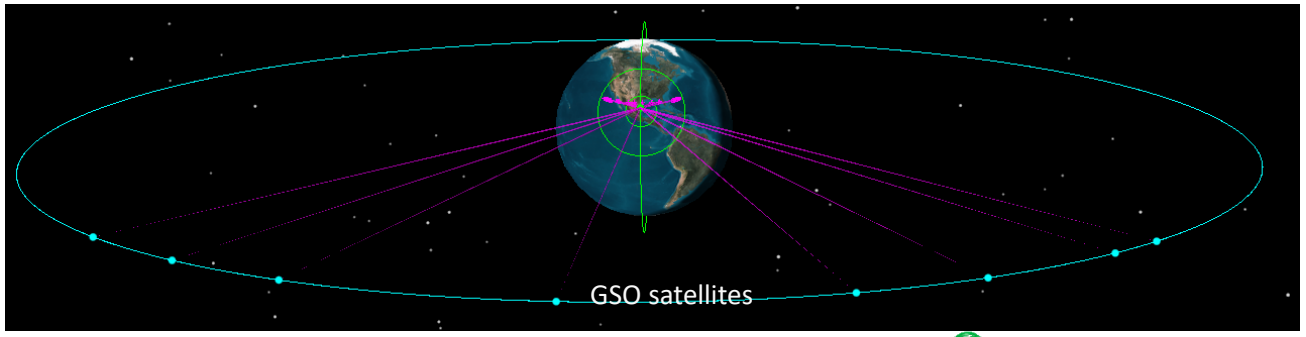
OneWeb

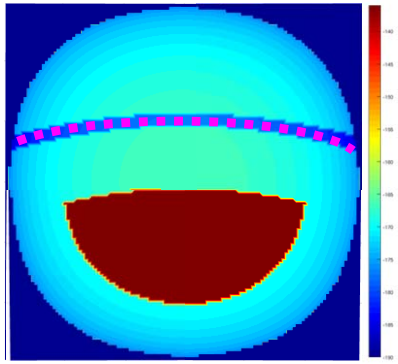
Inline Geometry with GSO



For each NGSO satellite position, there exists a locus of points on the surface of earth where inline (high interference) events with GSO systems are possible.

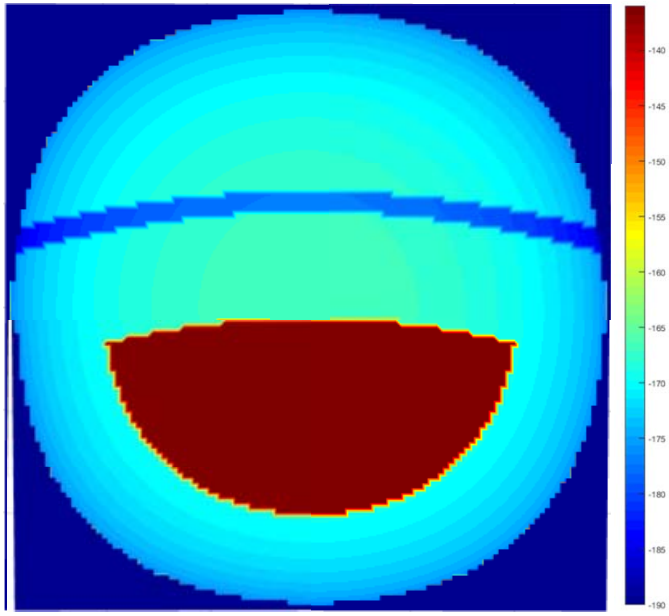
This creates an “alpha = 0” line, where there is no antenna discrimination at the GSO victim. This is why this case is the most critical geometry for EPFD.





OneWeb

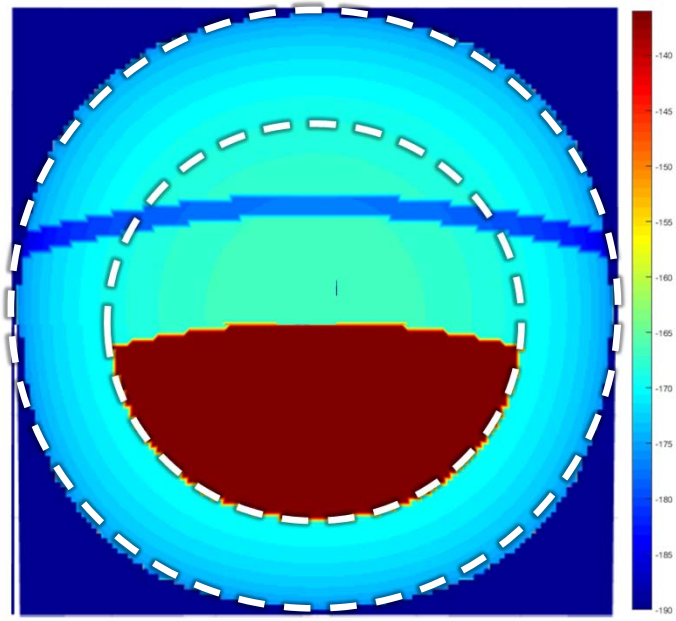
Elements of a PFD Mask



Worst-case PFD for all Az/El points visible from NGSO

Elements of a PFD Mask

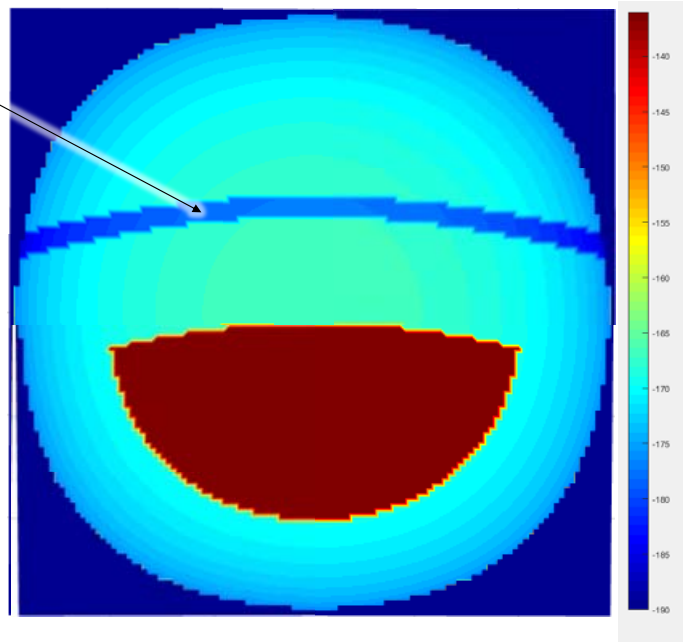
Outer circle is visible earth
Inner circle is service area



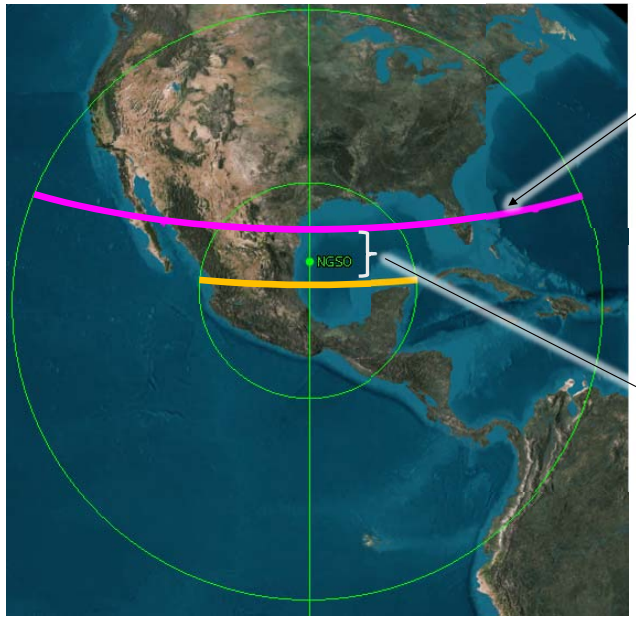
Worst-case PFD for all Az/El points visible from NGSO

Elements of a PFD Mask

Alpha = 0 line

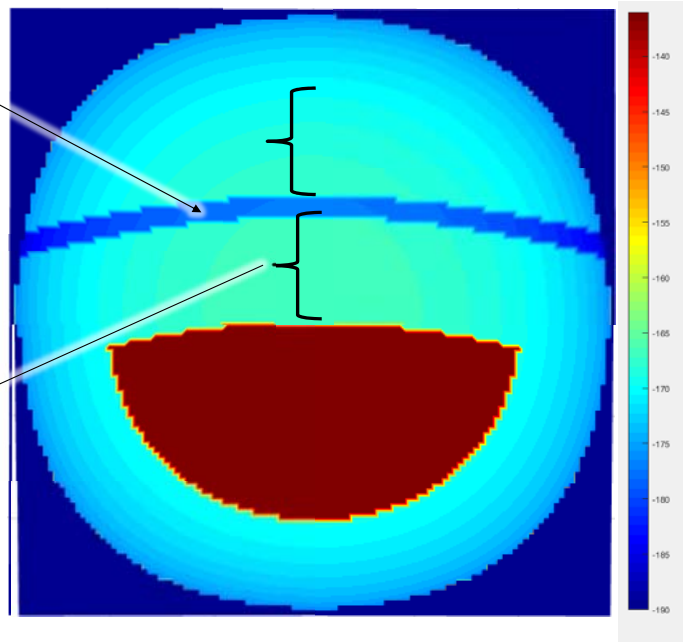


Elements of a PFD Mask

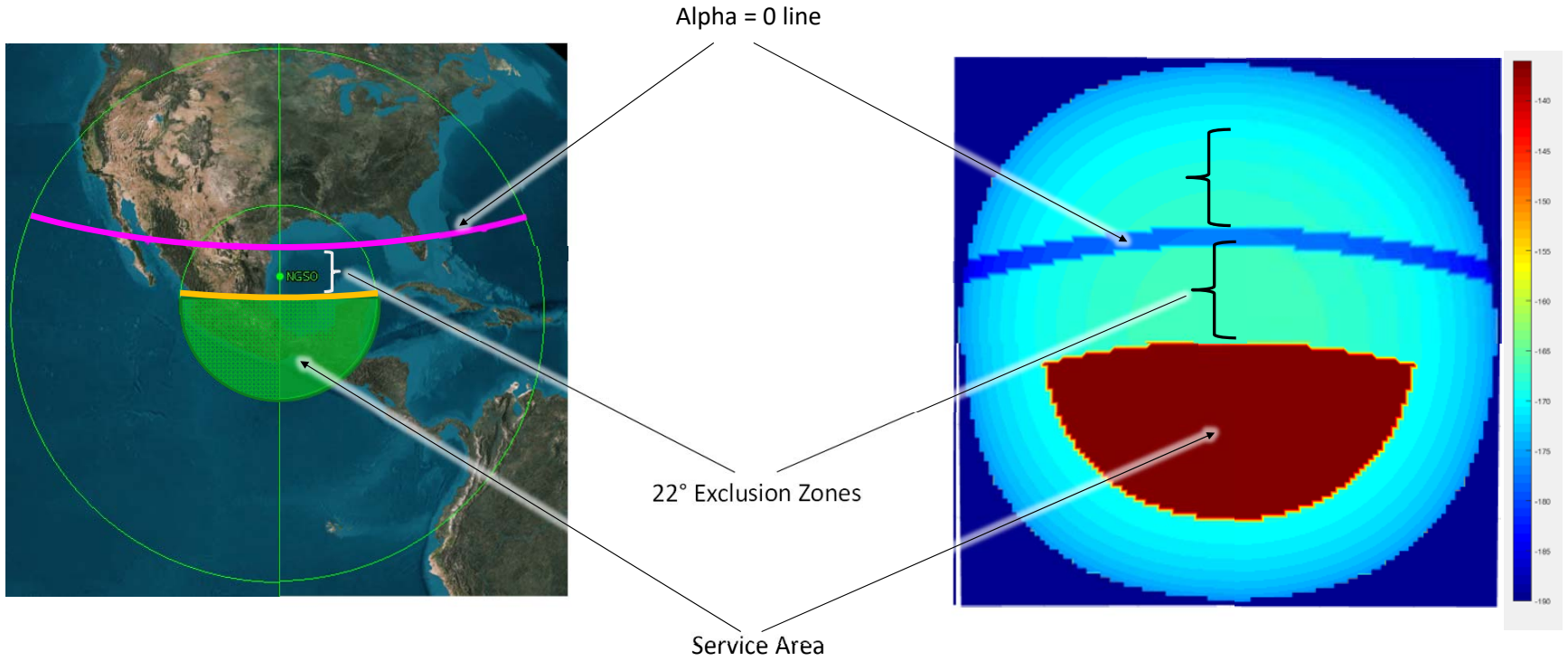


Alpha = 0 line

22° Exclusion Zones

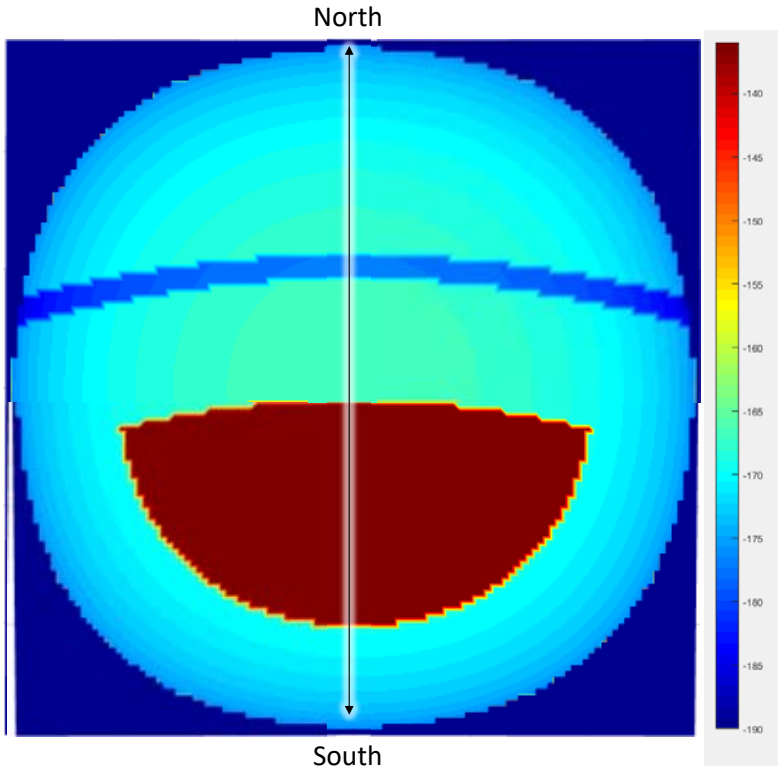


Elements of a PFD Mask



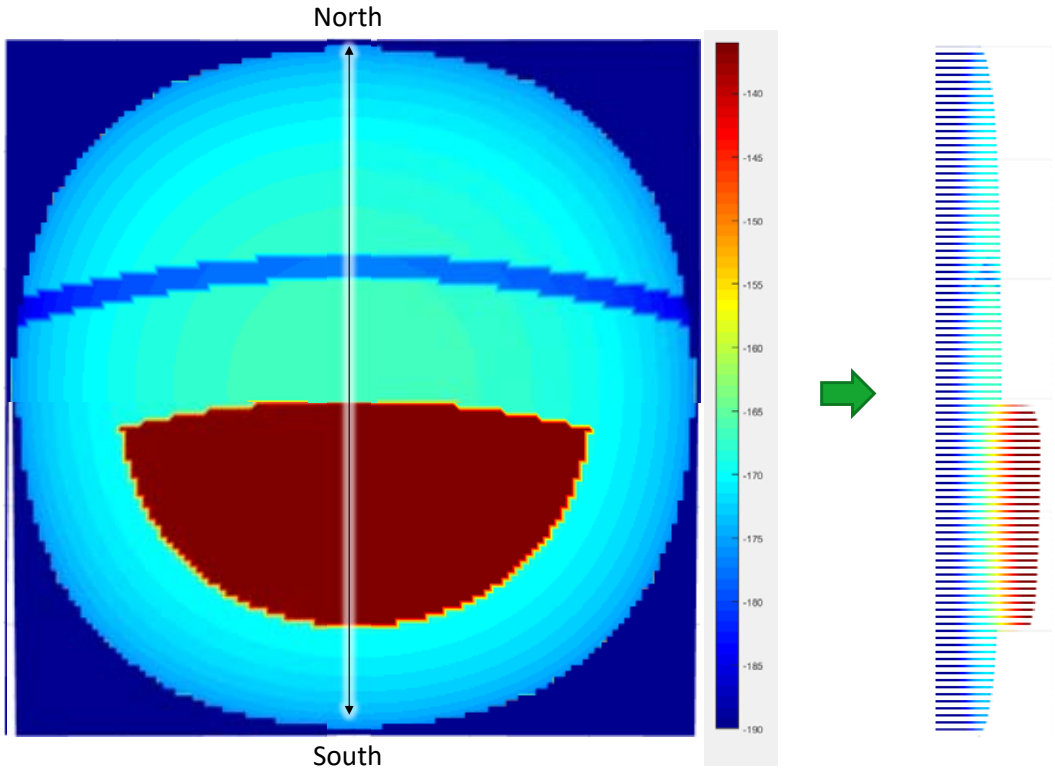
Take a North/South Cut

2D sample of 3D data



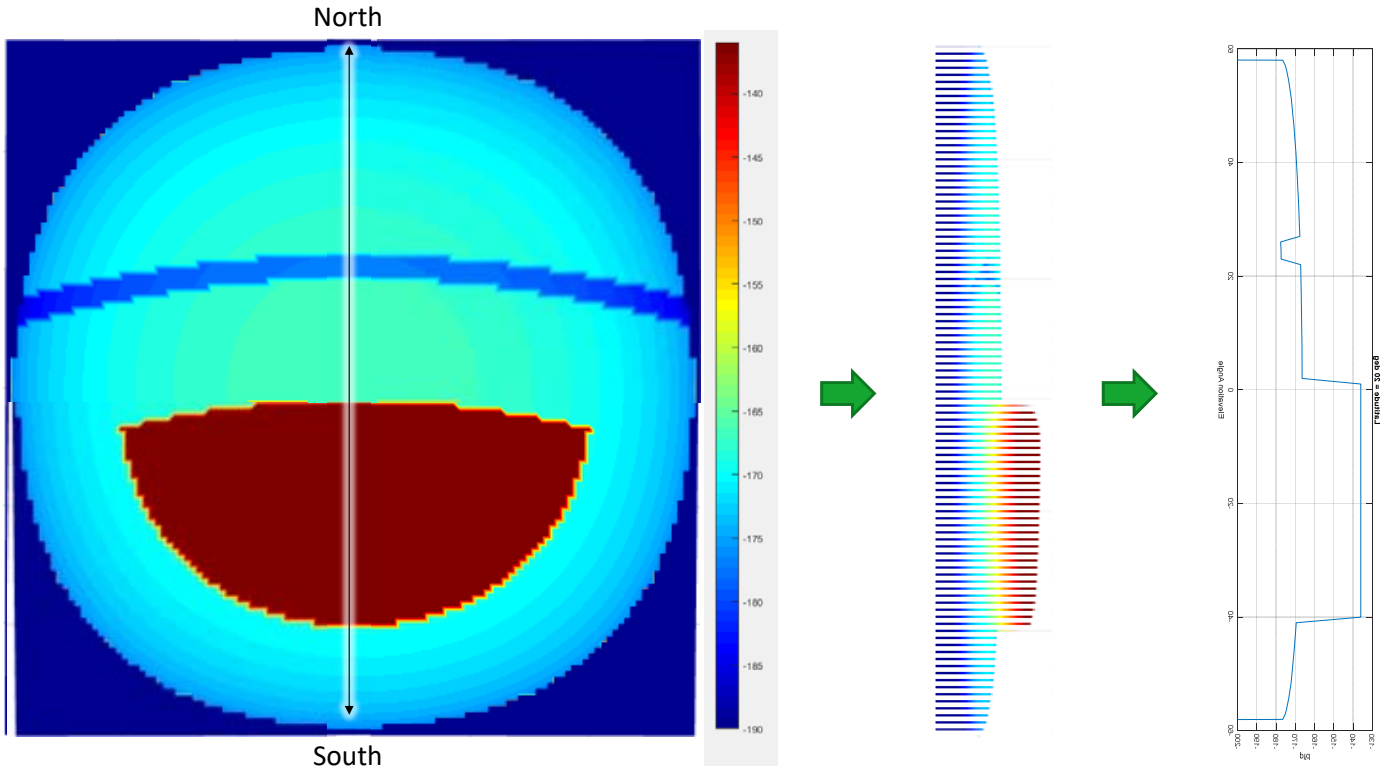
Take a North/South Cut

2D sample of 3D data



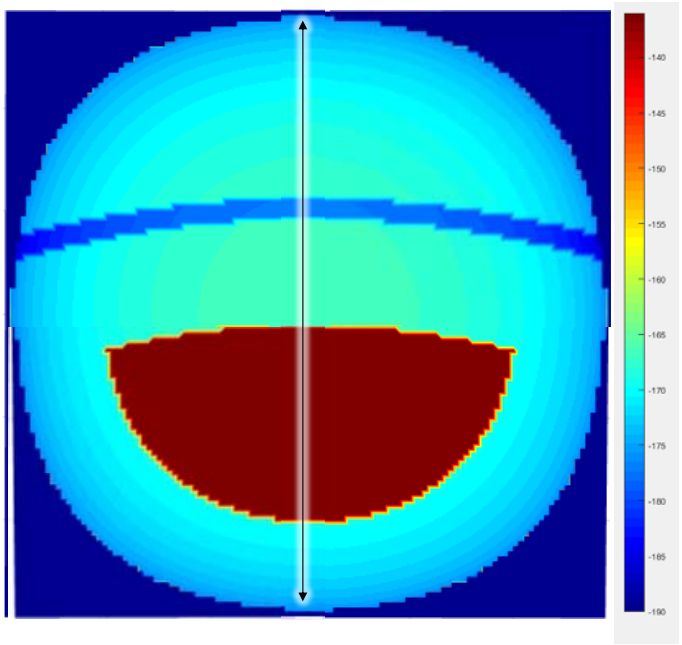
Take a North/South Cut

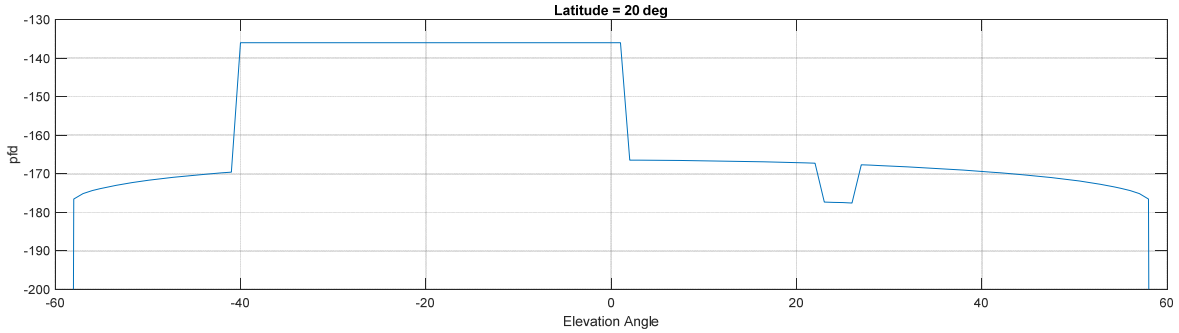
2D sample of 3D data



Take a North/South Cut

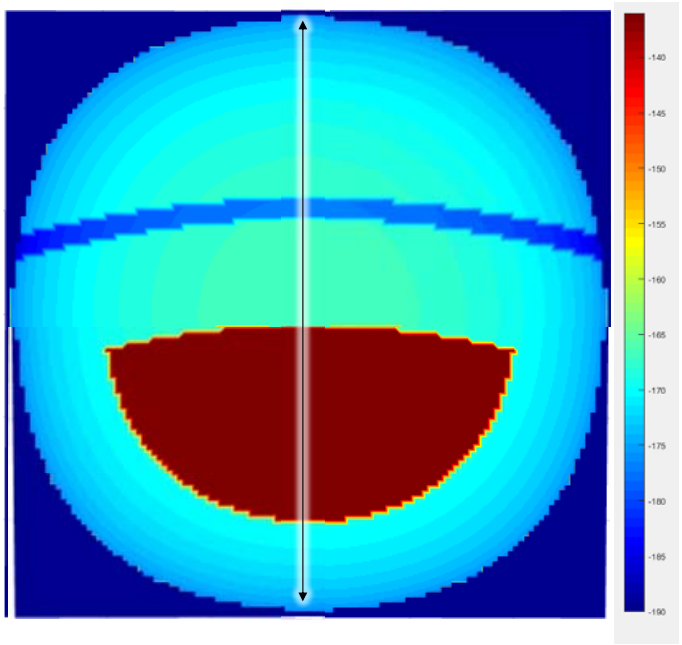
2D sample of 3D data

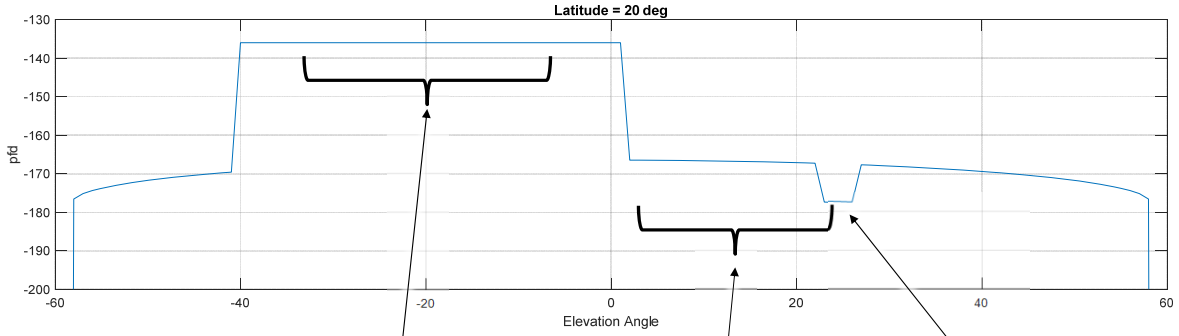




Take a North/South Cut

2D sample of 3D data





Service Area
(max PFD)

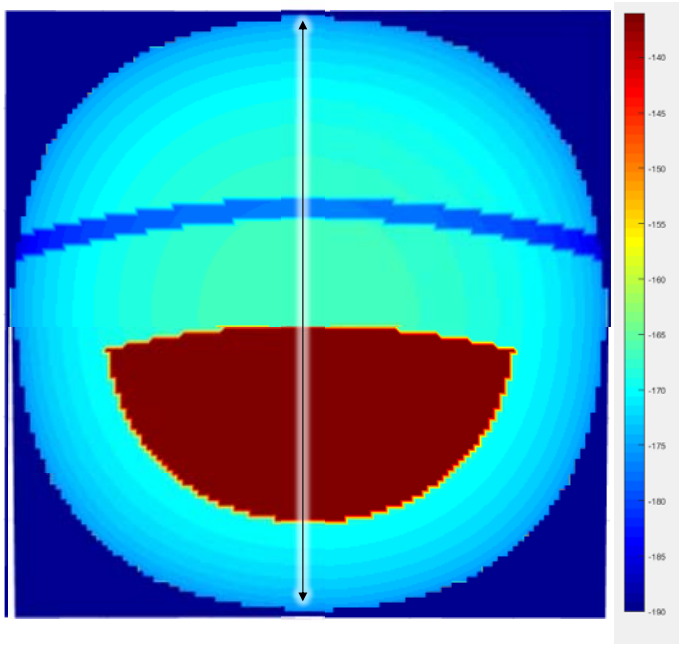
Alpha = 0 line
(minimum PFD)

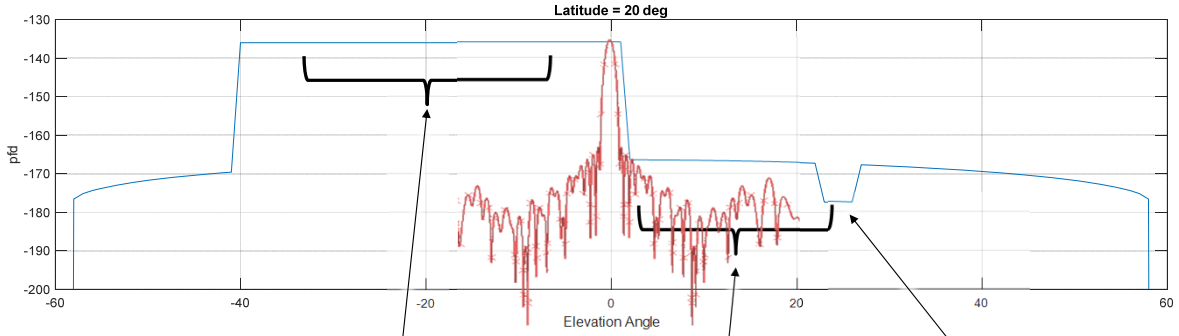
22° Exclusion Zone
(reduced PFD)

Take a North/South Cut

2D sample of 3D data

Beam can be steered anywhere within service area
“Mask” captures maximum PFD in any direction for satellite at this position



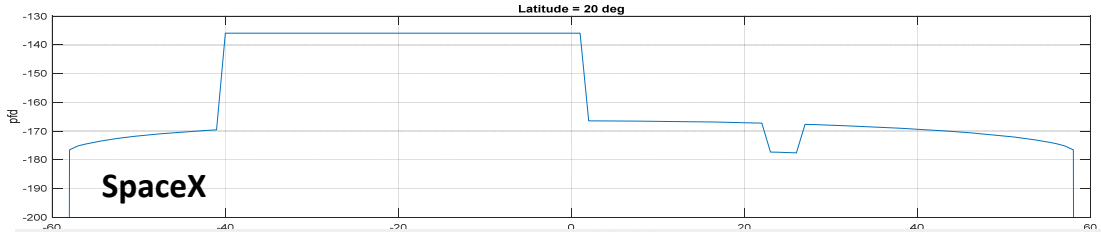


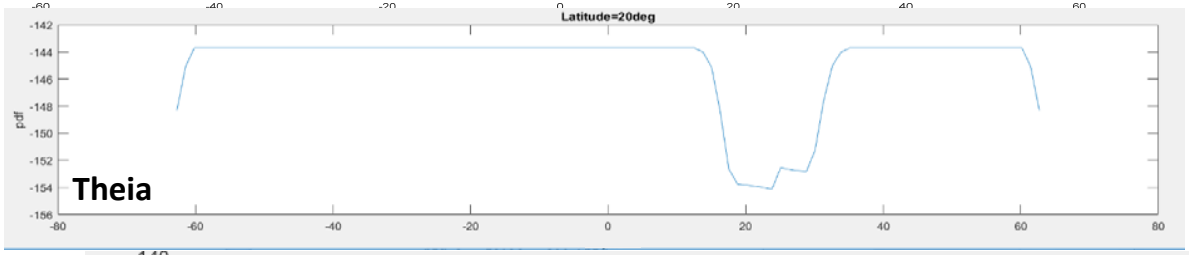
Service Area
(max PFD)

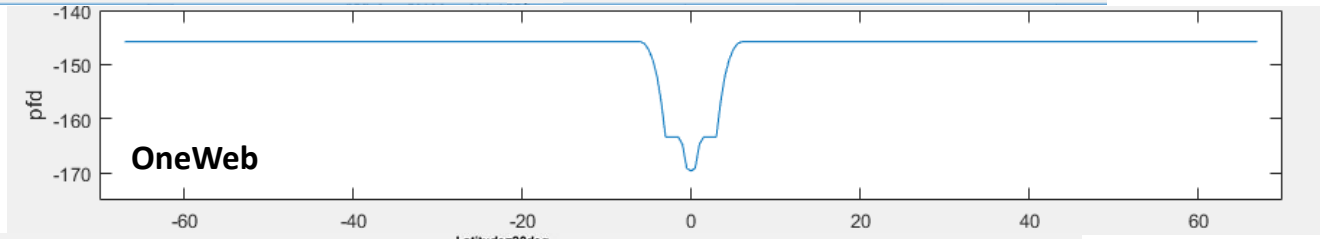
22° Exclusion Zone
(reduced PFD)

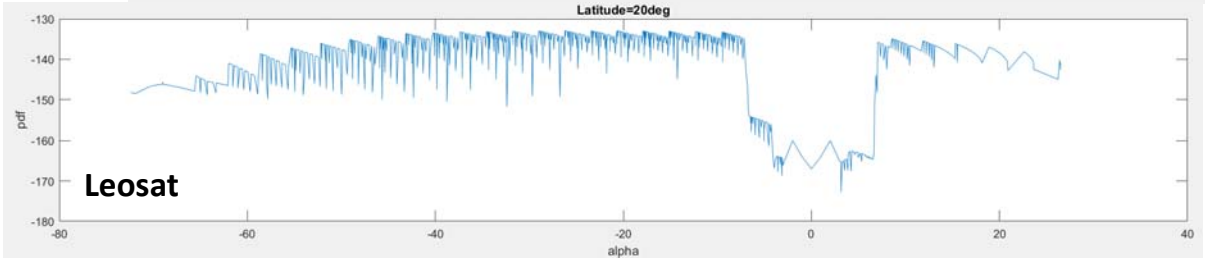
Alpha = 0 line
(minimum PFD)

Applicant PFD Masks

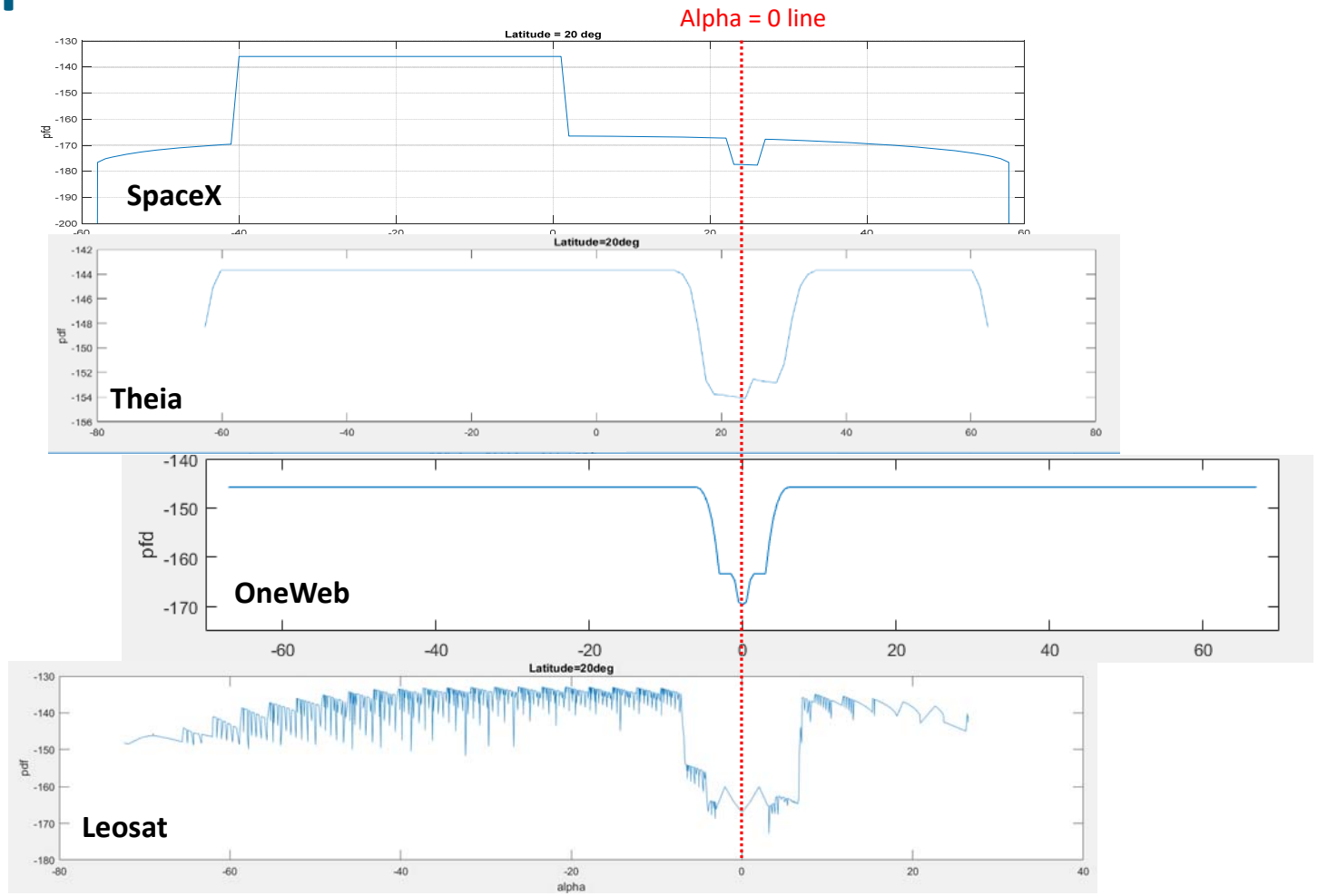




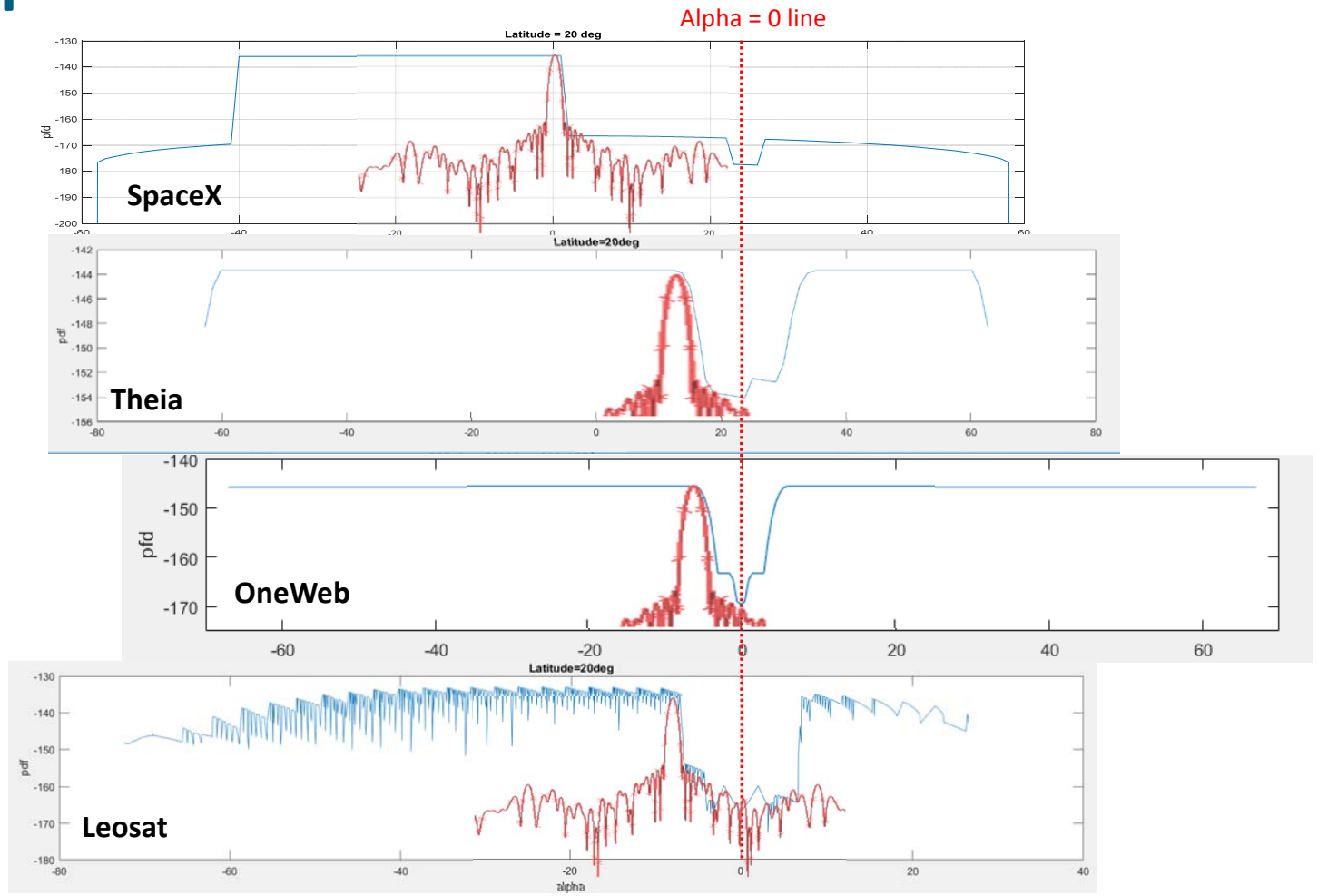




Applicant PFD Masks



Applicant PFD Masks



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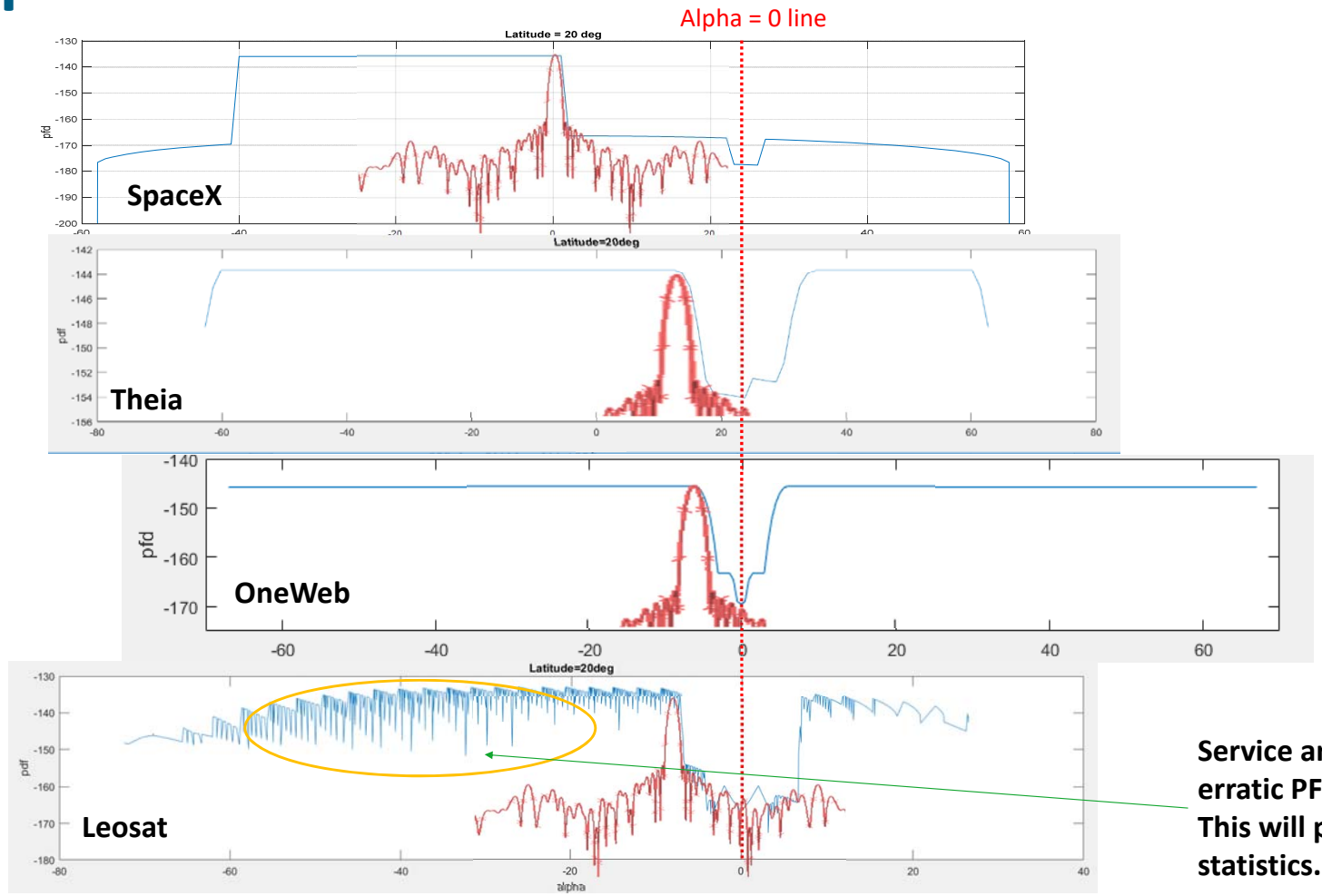


Service area of mask has very erratic PFD & no physical analog. This will produce optimistic EPFD statistics.

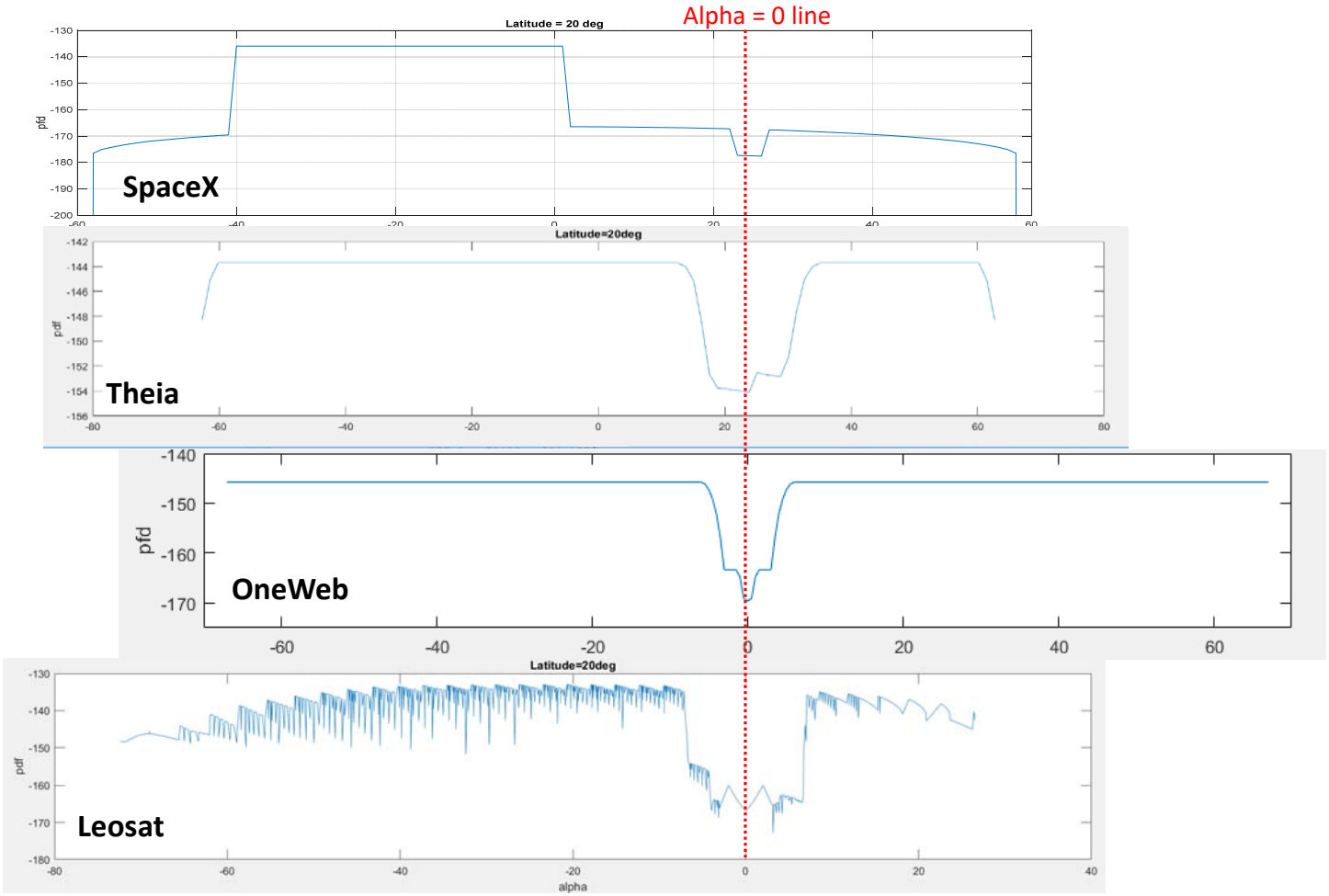
Key Input #2: Exclusion Angle

- EPFD is most commonly mitigated by using a GSO arc avoidance angle (also referred to as **exclusion angle**, **alpha angle**, or **x_zone**)

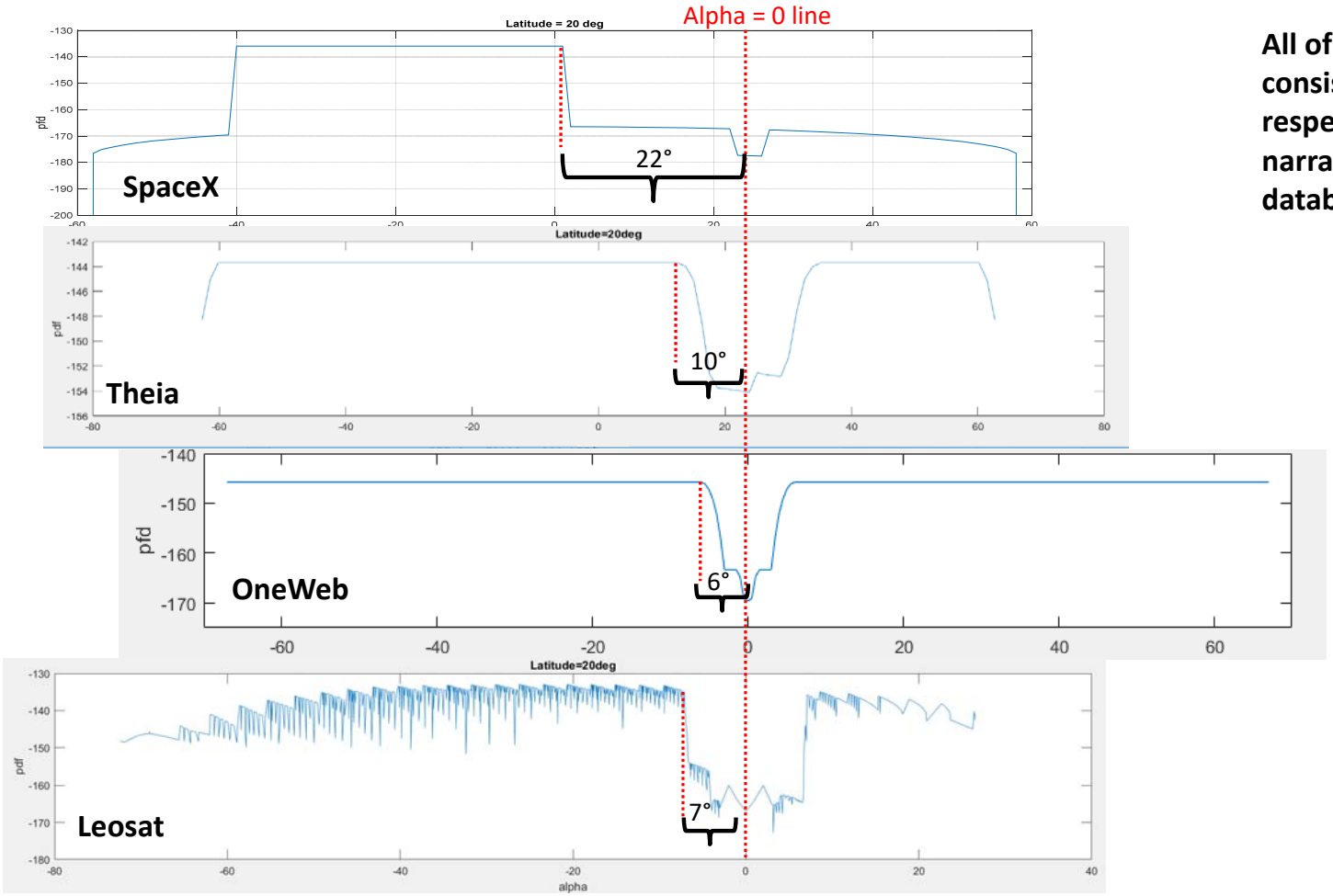
- NGSO systems self-prohibit operation within a few degrees of the GSO arc in order to reduce interference, taking advantage of antenna beam roll-off
  - No mainbeam-to-mainbeam interference geometries will happen, only sidelobe-to-mainbeam and sidelobe-to-sidelobe

- The “Exclusion Angle”, which the operator specifies in the SRS database, is critical in computing EPFD statistics and is also reflected in the shape of the PFD masks
  - It is the angle between the “alpha = 0 line” and the beginning of the “service area”

Key Input #2: Exclusion Angle

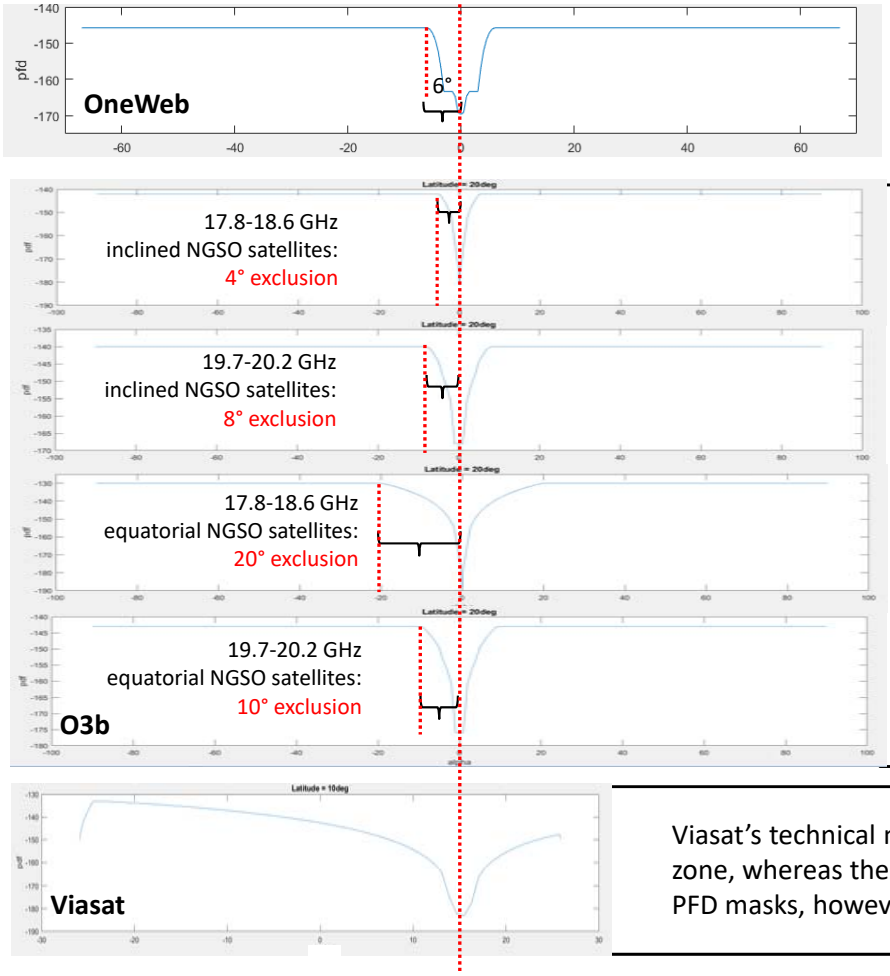


Key Input #2: Exclusion Angle



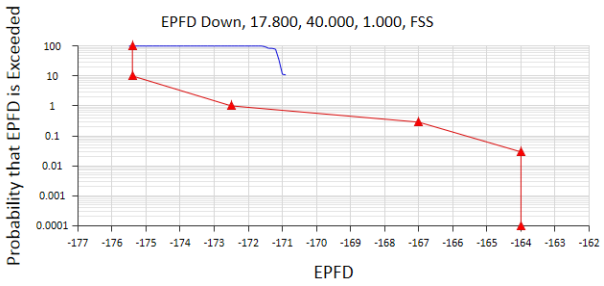
All of these exclusion zones are consistent between their respective applicants' technical narratives, PFD masks, and SRS databases

Key Input #2: Exclusion Angle



O3b specifies a 4° exclusion angle for all frequencies and orbit types, but the PFD masks indicate a variety of angles.

If the exclusion angle is changed to reflect the PFD mask, **O3b's system would appear to exceed EPFD limits.**



Viasat's technical narrative specifies a 5° exclusion zone, whereas the SRS databases specifies 3°. The PFD masks, however, reflect neither of these values.

Key Input #3: Earth Station Density

- The earth station density is used to simulate EPFD up calculations in Rec S.1503-2, and must be consistent with how the deployed system will actually operate

- Two parameters are defined in the SRS database: **density** and **avg_dist**

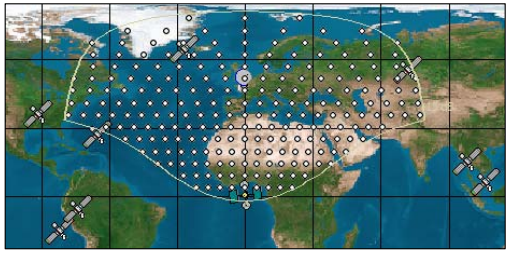
- 5.3 Non-GSO ES Deployment

  The use of ***avg_dist*** and ***density*** elements:

  - **density** (ES_DENSITY) - Average number of associated earth stations transmitting with overlapping frequencies per km^2 in a cell
  - **avg_dist** (ES_DISTANCE) – Average distance between co-frequency cells in kilometers

  These are required for uplink EPFD analysis to calculate the number of earth stations be populated:

  NUM_ES = ES_DISTANCE * ES_DISTANCE * ES_DENSITY



- To accurately represent a single earth station, density should be equal to $1/avg\_dist^2$

Key Input #3: Earth Station Density

	As specified		Actual	
	avg_dist	density	1/avg_dist²	Error
OneWeb	570	3.0800E-06	3.0779E-06	-0.07%
SpaceX	51.3	3.8000E-04	3.7998E-04	0.00%
Theia	500	4.0000E-06	4.0000E-06	0.00%
Viasat	**1798**	3.0970E-07	3.0933E-07	-0.12%
Leosat	560	1.0000E-06	3.1888E-06	218.88%
O3b	590	2.8182E-07	2.8727E-06	919.35%
Kepler	470	1.0000E-06	4.5269E-06	352.69%

Specifying a user density that is many times lower than the actual operating environment will artificially lower EPFD results.

Key Input #4: Constellation Parameters

The worst-case geometry (WCG) is the key test-point for EPFD validation; it is understood to result in the highest EPFD values. All other victim geometries are therefore understood to have lower EFPD.

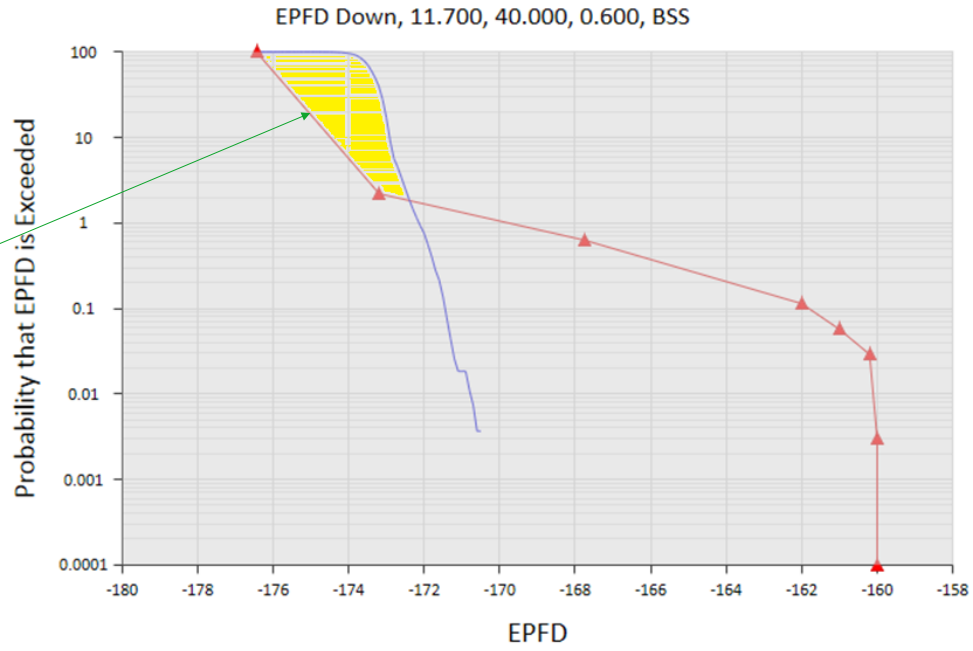
- Rec. ITU-R S.1503-2 assumes a single set of constellation orbital parameters {*a, e, i*} in the WCG algorithm, to determine the locations to place the GSO victim system.
- The algorithm is not designed to find WCG for multi-altitude, multi-inclination constellations. Therefore, any EPFD results that are presented for these constellations cannot be taken to be representative of true worst-case results, meaning **higher EFPD is possible in other geometries**.
- For example, SpaceX has five different sets of *{a, e, i}*, and presents EPFD results that are not actually worst-case. A review of the SpaceX inputs has revealed many cases that do not meet EPFD limits, and require further inquiry.
- From Annex 21 to Working Party 4A Chairman's Report, 18 October 2016:
  "*If there are multiple sets of {a, e, i} then there would need to be multiple runs to check each sub constellation's WCG. Each run would calculate the WCG based upon one sub-constellation's characteristics. Then the run would calculate the run time and duration based the method described in the paragraphs above. Each run would include all satellites in the constellation to calculate the aggregate EPFD and would have to pass the test against the limits in RR Article 22.*"

Interpreting EPFD

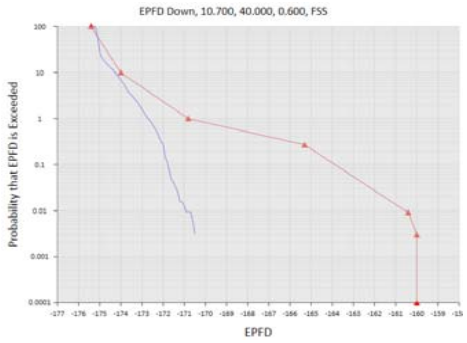
Red Line represent the limits from ITU Radio Regulations Article 22
The blue line is the operators EPFD Performance

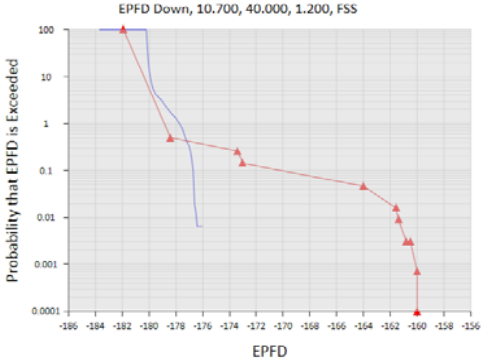
The blue line must, in all instances, stay to the left of the Red Line

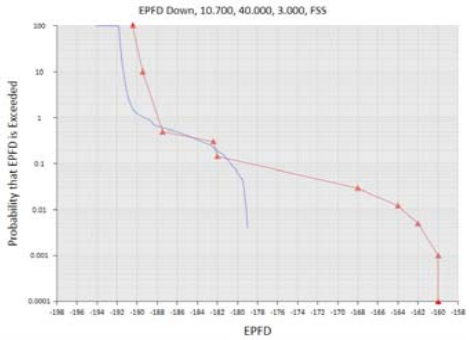
Highlighted area shows where system design exceeds EPFD limits

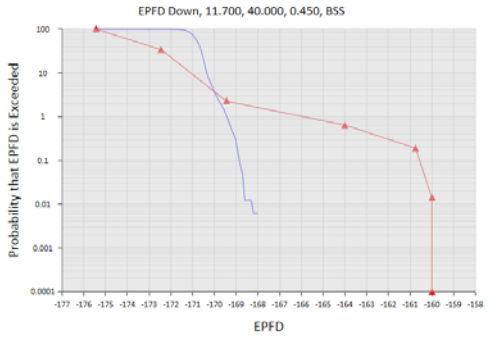


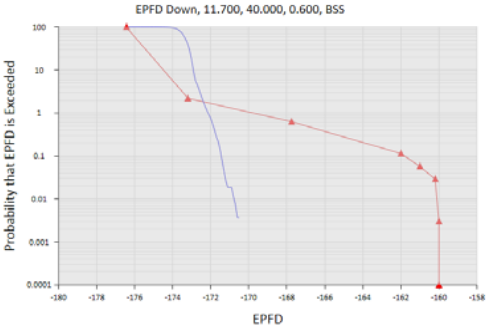
SpaceX EPFD Results for GSO victim ES at 30°N

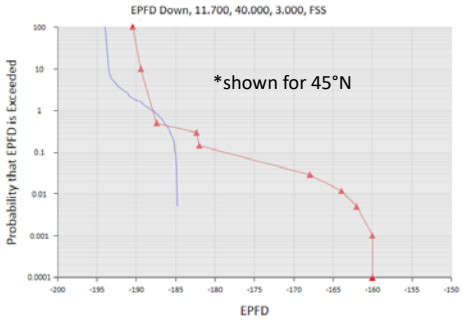


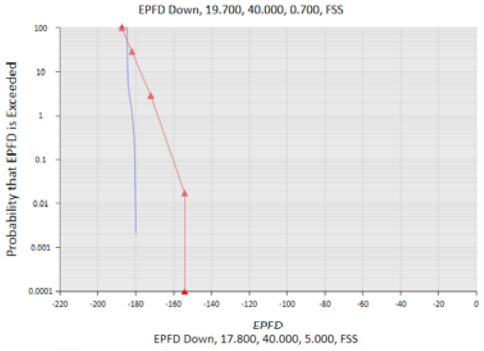


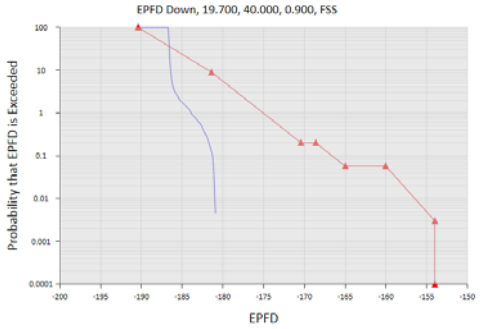


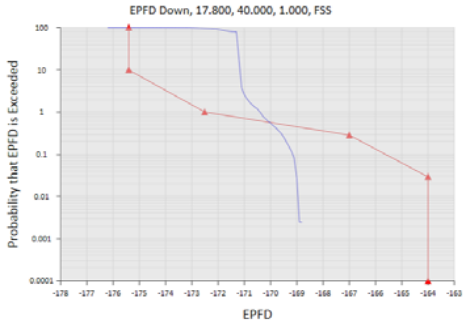


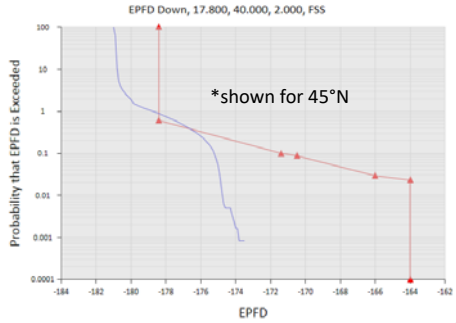


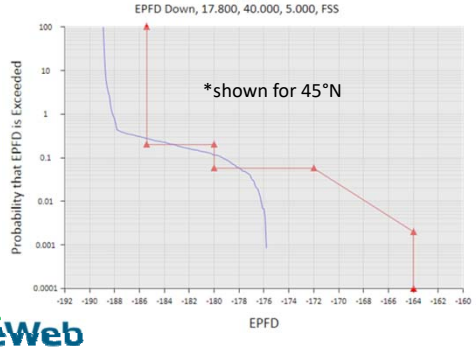










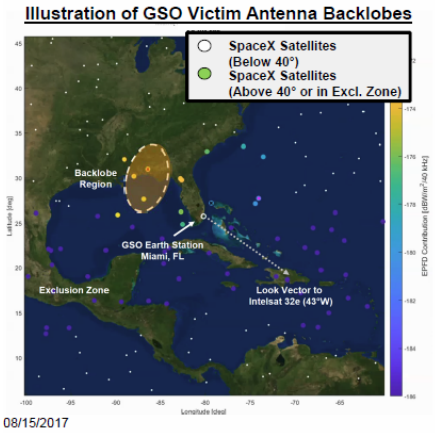


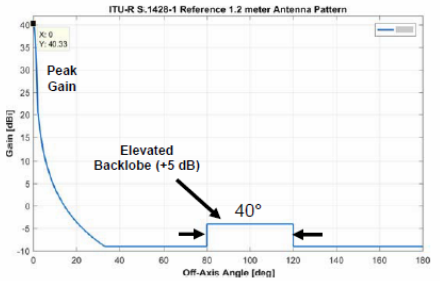
EPFD exceedances are shown for 11 of 19 GSO victim antenna types.

Note: These examples, while demonstrating failures, may or may not represent the actual "worst case" geometries.

All GSO system geometries must be considered and protected

- As SpaceX states, numerous EPFD exceedances may result from their NGSO satellites radiating into the backlobes of GSO victim earth stations
- These real geometries are not extreme, and are protected under Radio Regulations
- Beam assignment or time usage may not ensure EPFD compliance – it is impossible to avoid all backlobes of potential GSO pointing vectors for a given point on Earth





While PFD reduction may result in a demonstrated EPFD compliance (assuming the WCG is also valid), this analysis needs to be provided

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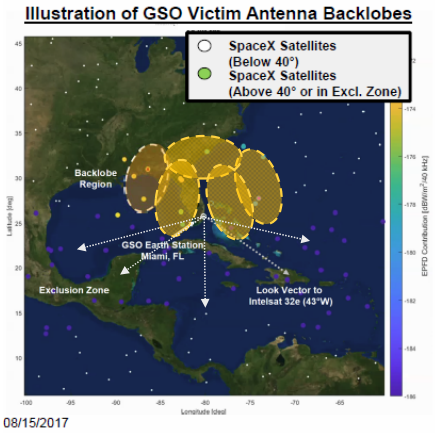

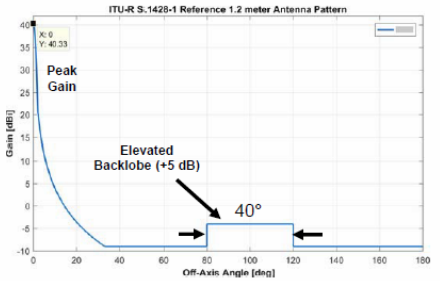

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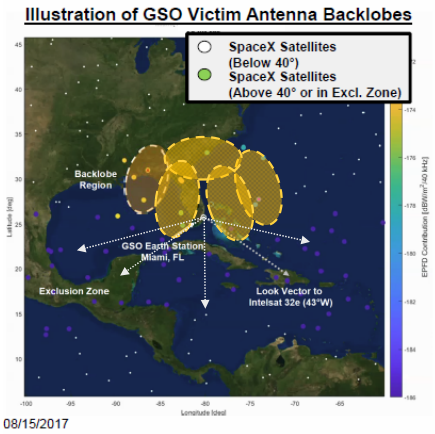
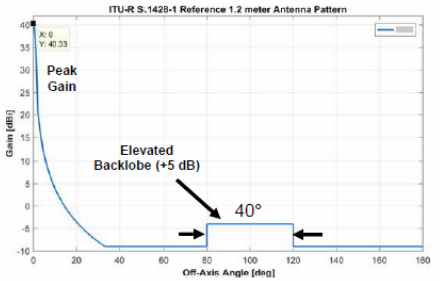
ITU Req. S14-28 requires NGSO to protect all GSO antennas per this pattern.





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Conclusion

- Numerous anomalies and inconsistencies in some applicants' EPFD showings warrant close inspection by the FCC to confirm validity
- Without further inquiry, multiple NGSO systems could exceed EFPD limits when operational
- Therefore, the FCC should exercise its authority to request additional information from NGSO applicants regarding the creation and validity of files submitted to show EPFD compliance
- This especially applies to applicants that have not yet submitted any EPFD validation data