EXHIBIT A - TECHNICAL ATTACHMENT

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1. SCOPE AND PURPOSE

This attachment contains technical information required under Part 25 of the Commission's rules.

2. OVERALL DESCRIPTION

Umbra requests Commission authorization to deploy a constellation of up to six (6) non-geostationary orbit ("**NGSO**") satellites in up to six distinct orbital planes. Umbra satellites will use advanced synthetic aperture radar ("**SAR**") capabilities to offer extremely high-resolution monitoring while reducing costs and streamlining the satellite manufacturing process.

2.1. Orbital Information

The Umbra SAR Constellation will consist of up to six (6) satellites divided across six orbital planes. The Umbra satellites will include a propulsion system and, through regular corrective propulsive maneuvers by Umbra, are anticipated to remain in their planned orbit within the ranges given below:

Table 1. Orbital Parameters for Each Orbital Plane

Satellites per Plane	1-2
Inclination	97.5 ± 2º
Orbital Period	5,734 ± 67 secs
Apogee	555 ± 55 km
Perigee	555 ± 55 km
Argument of Perigee	N/A – Near Circular Orbit (583 km nominal)
Active Service Arc	Full Orbit

Representative orbital information is included in the Schedule S.

2.2. Spectrum

The Umbra SAR Constellation will operate in the following frequency bands:

Table 2. Umbra SAR Spectrum Allocations

Link Name	Band (MHz)	Center Frequency (MHz)[1]	Bandwidth (MHz)
Mission Data Downlink	8025-8400	8150	250
EESS (Active) Band 1	9200-10400	9800	1200
EESS (Active) Band 2	9300-9900	9600	600
TT&C Downlink	2200-2290	2254	0.1
TT&C Uplink	2025-2110	2080	0.1

2.3. Technology and Operations

Umbra satellites will use advanced SAR capabilities to offer extremely high-resolution monitoring of the Earth's surface with on-demand delivery of SAR imagery. Umbra's systems are designed to avoid any harmful interference with other satellite systems—including other EESS systems—and protected terrestrial systems. *See infra* Section 5. They will meet all applicable power flux- density (PFD) and other coexistence requirements even in a worst-case configuration, as discussed below. *See id*.

Moreover, due to the on-demand nature of Umbra's service, its payload and sensing transmissions will occur infrequently and with low PFD on the ground, further minimizing the risk of interference while these systems are active. *See infra* Section 6.

[1] The proposed center frequencies specified in the table are subject to coordination with federal operators and other users and accordingly may change.

2.4. Ground Station Locations

Umbra has contracted with Kongsberg Satellite Services (“KSAT”) and is considering Amazon Web Services (“AWS”) Ground Stations for ground-based telemetry, tracking, and command (“TT&C”) and mission data downlink services for the satellites. KSAT and AWS work with Umbra, national regulatory authorities and international regulatory authorities to obtain all necessary licenses for station operations and transmission approval.

The sites listed in [continued on the following page]

Table *3* below are part of the KSAT-lite ground network and AWS ground terminals and will be utilized by the satellites for both S-Band uplink and downlink as well as X-Band downlink. Utilization of these sites will be coordinated with federal operators. As indicated in Table 3, Umbra will not communicate with any U.S. ground station.

[continued on the following page]

Table 3. International Ground Sites Requested

Site	Provider	Antenna Size / Band	Lat	Long
Svalbard, Norway	KSAT	3.7-m / S 3.7-m / X	78.2 N	15.3 E
Inuvik, Canada	KSAT	3.7-m / S 3.7-m / X	68.2 N	133.3 W
Punta Arenas, Chile	KSAT	3.7-m / S 3.7-m / X	53 S	70 W
Awarua, New Zealand	KSAT	3.7-m / S 3.7-m / X	46.5 S	168.4 E
Dublin, Ireland	AWS	3.7-m / S 3.7-m / X	53.41 N	6.23 W
Stockholm, Sweden	AWS	3.7-m / S 3.7-m / X	59.65 N	16.58 E
Zallaq, Bahrain	AWS	3.7-m / S 3.7-m / X	26.05 N	50.5 E
Cape Town, South Africa	AWS	3.7-m / S 3.7-m / X	34.03 S	18.72 E
Singapore	AWS	3.7-m / S 3.7-m / X	1.36 N	103.99 E
Seoul, South Korea	AWS	3.7-m / S 3.7-m / X	37.31 N	127.14 E
Tokyo, Japan	AWS	3.7-m / S 3.7-m / X	35.81 N	140.13 E
Mumbai, India	AWS	3.7-m / S 3.7-m / X	19.15 N	73.01 E
Sydney, Australia	AWS	3.7-m / S 3.7-m / X	34.04 S	150.77 E

Table 4. KSAT S-Band Ground Antenna Specification

Size	**3.7-m Diameter**
Radiation Pattern	ITU-R S.465-6
EIRP	44.8 dBW
Maximum Gain	35.4 dBi
Minimum Elevation	5 deg
Azimuthal Range	360 deg
Polarization	RHCP

Table 5. KSAT X-Band Ground Antenna Specification

Size	**3.7-m Diameter**
Half Power Beamwidth	0.8 degrees
Minimum Output Power	0 W
EIRP	NA
Maximum Gain	47 dBi
Minimum Elevation	5 deg
Azimuthal Range	360 deg
Polarization	RHCP

Table 6. AWS X-Band Ground Antenna Specification

Size	5.4-m Diameter
Radiation Pattern	ITU-R S.465-6
EIRP	53 dBW
Maximum Gain	30.5 dB/T
Minimum Elevation	5 deg
Azimuthal Range	360 deg
Polarization	RHCP

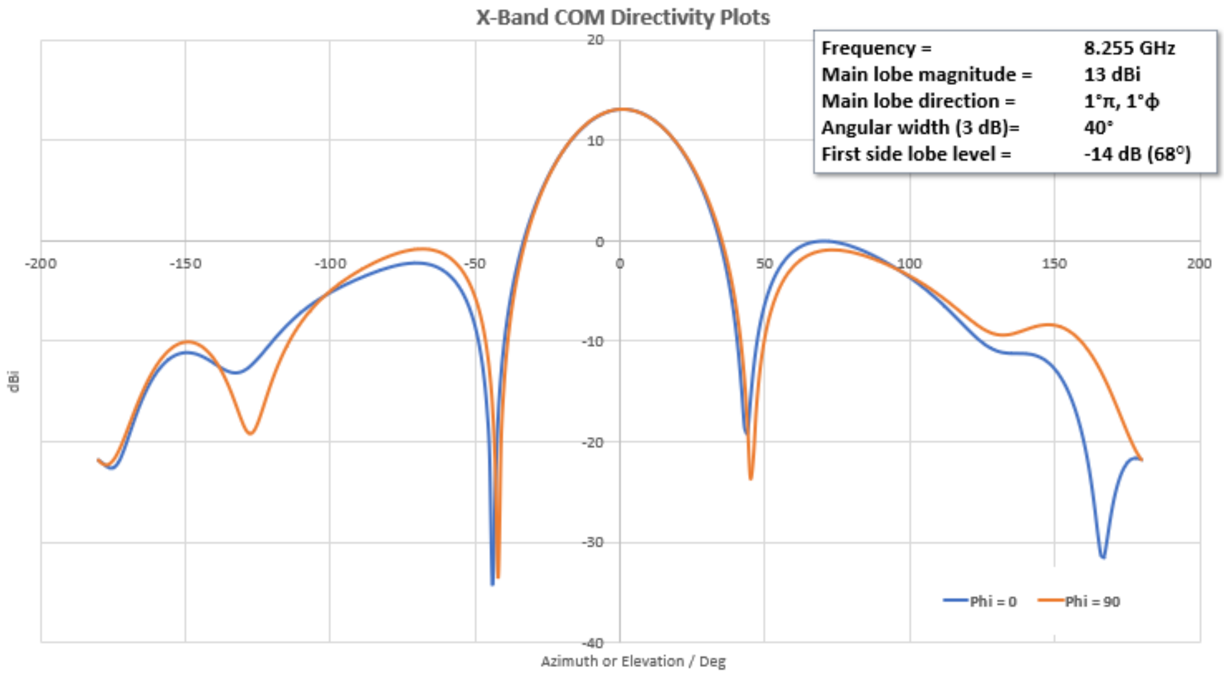
3. Predicted Space Station Antenna Gain Patterns and Contours

Space stations in the Umbra SAR Constellation will use several fixed antennas for payload and TT&C communications, as well as SAR sensing. The gain patterns and contours for each of these antennas are illustrated below.

3.1. X-Band Mission Data Downlink (8025-8400 MHz)

The Umbra X-Band mission data downlink beam will have a maximum EIRP of 23.2 dBW in a 250 MHz channel from 8025-8275 MHz, using RHCP polarization, with the gain patterns shown in Figure 1 and Figure 2. The constellation will operate using X-Band communications by means of a wider beamwidth patch antenna for Umbra-2001 and a narrower beamwidth and slightly higher gain patch antenna for all subsequent spacecraft. The former is demonstrated by gain patterns and contours in Figure 1 and Figure 3 below. All subsequent spacecraft will utilize the patch antenna as depicted below in Figure 2 and Figure 4.

Figure 1. Umbra X-Band Downlink Gain Pattern (2x2)



*Vendor supplied antenna test data.

Figure 2. Umbra X-Band Downlink Gain Pattern (4x4)

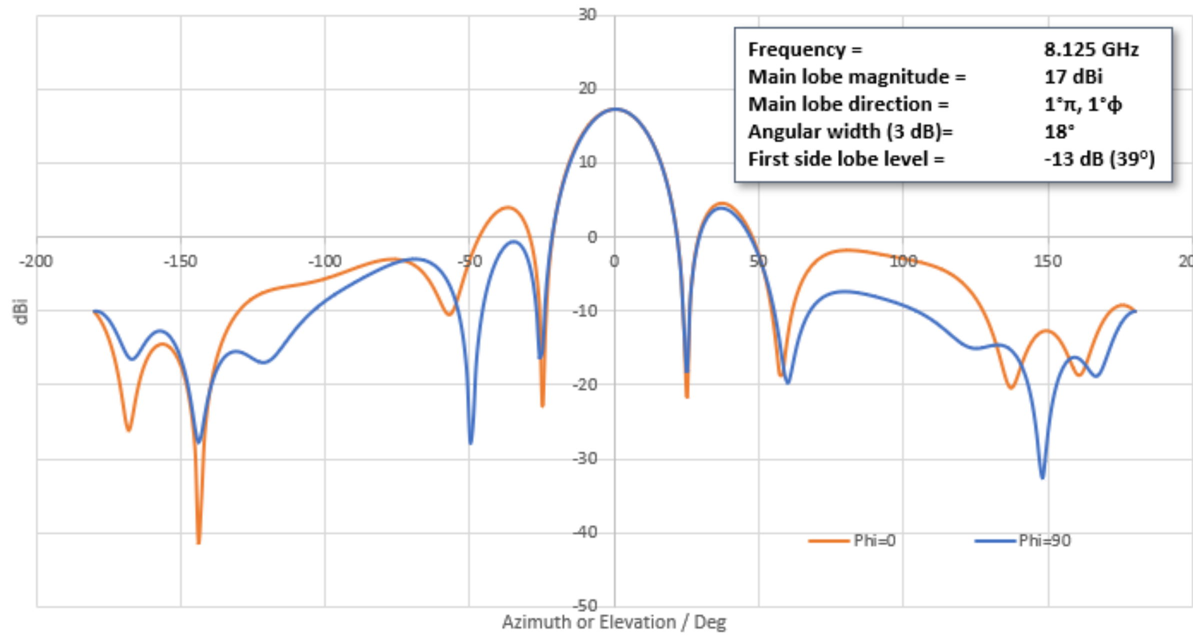


Figure 3. Umbra X-Band Gain Contours (Svalbard, 2x2)

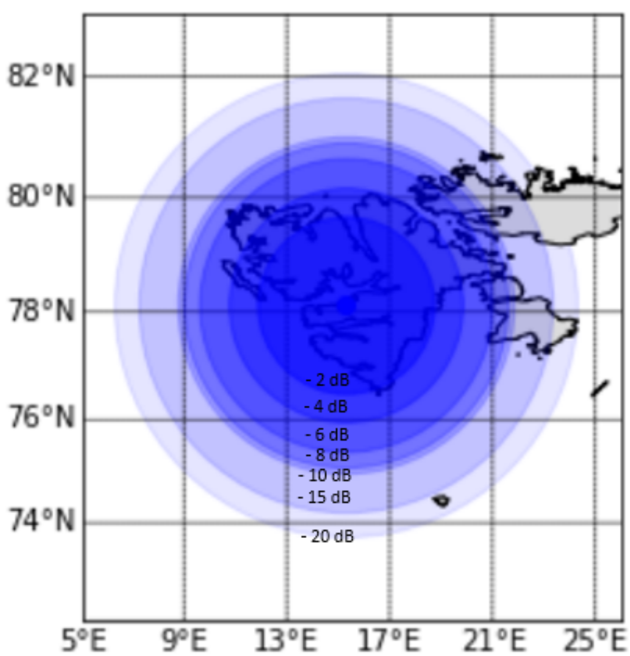
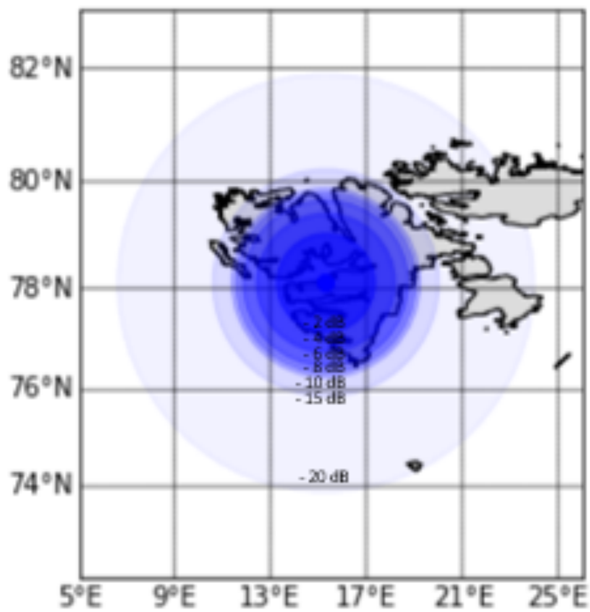


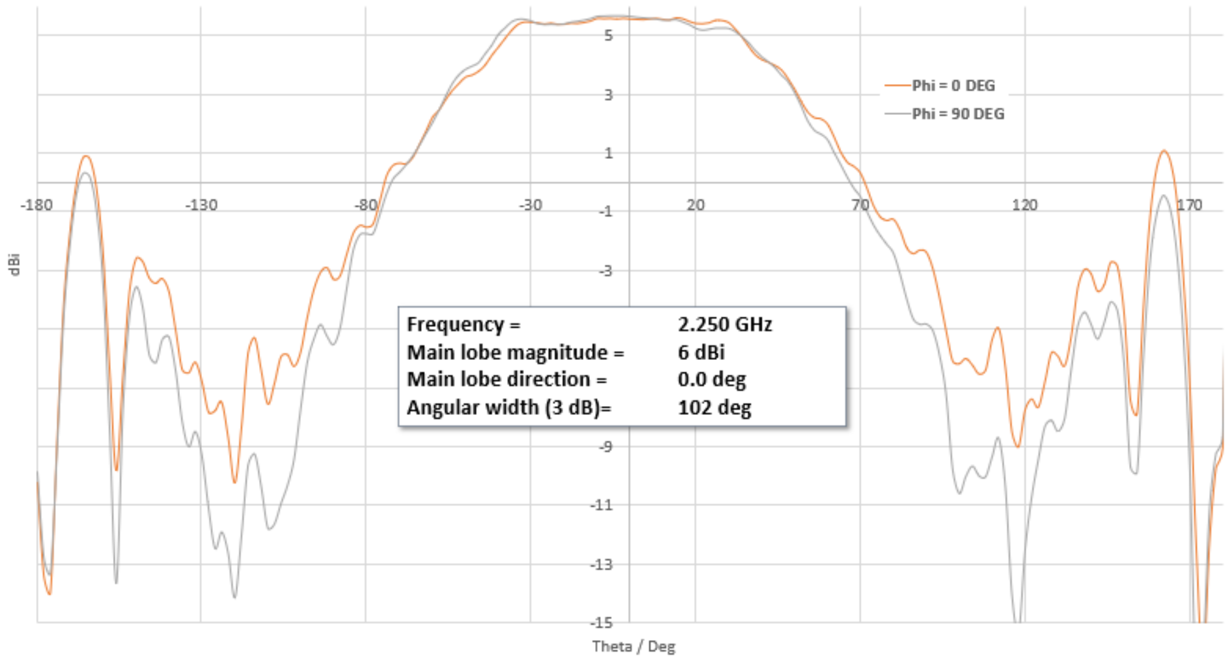
Figure 4. Umbra X-Band Gain Contours (Svalbard, 4x4)



3.2. S-Band TT&C Downlink (2200-2290 MHz)

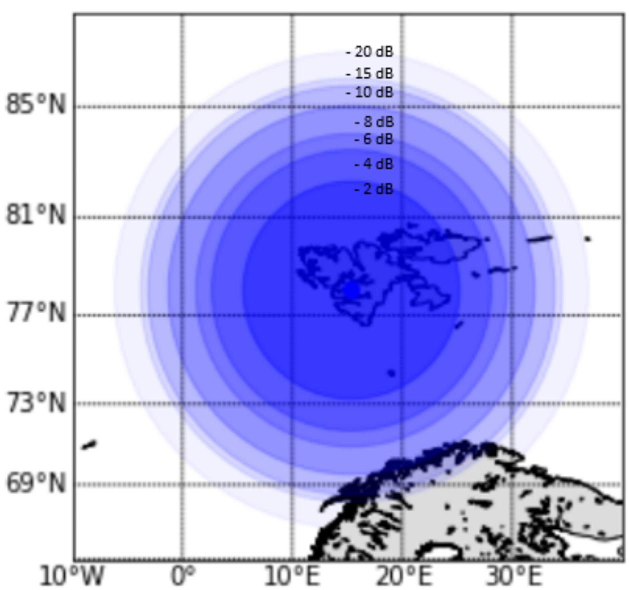
The Umbra S-Band TT&C downlink beam will have a maximum EIRP of -8.5 dBW in a 100 kHz channel centered at 2254 MHz, using RHCP polarization, with the gain patterns shown in Figure 5 below.

Figure 5. Umbra S-Band TT&C Downlink Gain Pattern



*Vendor supplied antenna test data.

Figure 6. Umbra S-Band Gain Contours (Svalbard)

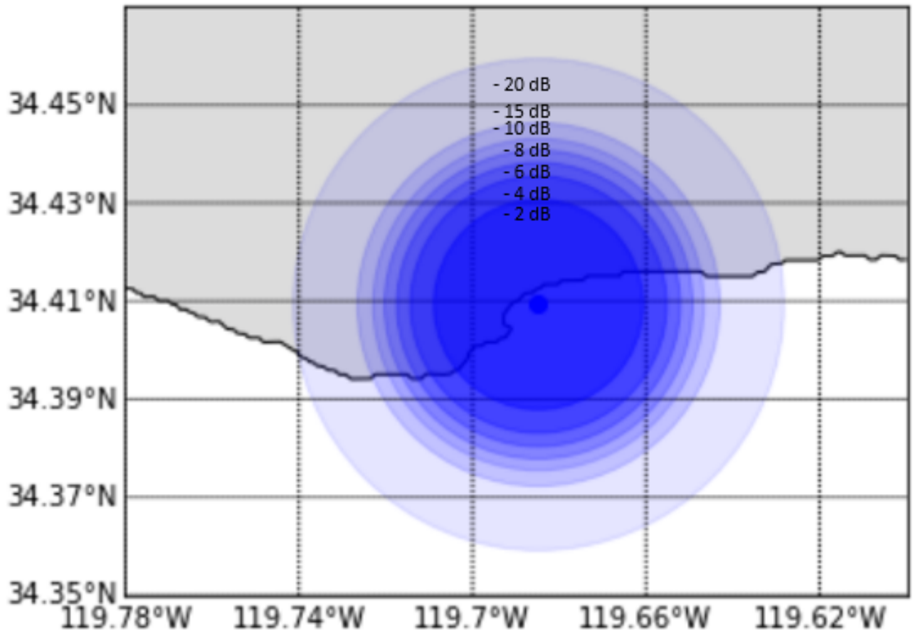


3.3. X-Band SAR Antenna

The Umbra X-Band SAR beam will have a maximum EIRP of 78.5 dBW in two alternative frequency channels centered at 9600 MHz and 9800 MHz with bandwidths of 600 MHz and 1200 MHz respectively, using linear polarization, with the gain pattern shown in Figure 7 below:

Figure 7. Umbra X-Band SAR Gain Pattern

Figure 8. Umbra SAR Gain Contours (Santa Barbara)



4. CESSATION OF EMISSIONS

Each active satellite transmission chain (channel amplifiers and associated power amplifier) can be individually turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by Section 25.207 of the Commission's rules.

5. COMPLIANCE WITH PFD LIMITS AND OTHER SHARING CRITERIA

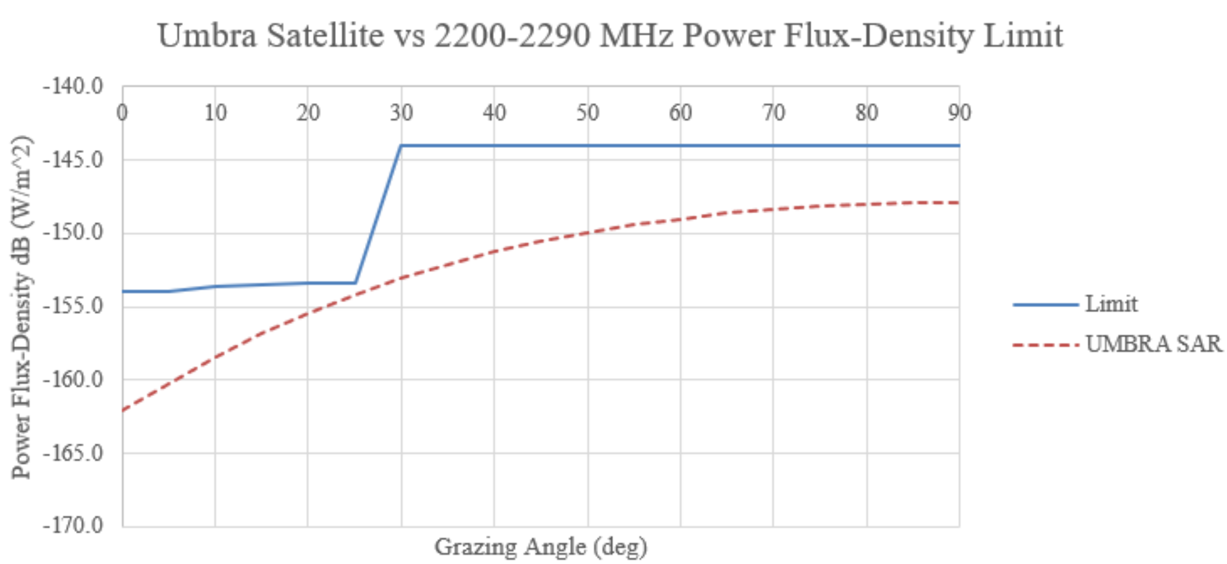
This section demonstrates that Umbra satellites will operate with PFD below specified limits. For each band shown, a worst-case approach was taken to show compliance in even the most outlying case. These settings include the worst-case (for PFD purposes) operational altitude of 500-km.

5.1. Power Flux Density in the band 2200-2290 MHz

In accordance with note US303 of the U.S. Table of Frequency Allocations the PFD at Earth's surface from non-Federal stations shall not exceed -144 to -155 dBw/m^2/kHz, depending on the angle of arrival, in accordance with ITU Radio Regulation 21.16. *See* 47 C.F.R. § 2.106 n. US303.

Figure ***9.*** **Nominal Power Flux Density for S-Band (2200-2290 MHz)**9 shows that each Umbra satellite complies with the PFD of ITU Radio Regulation 21.16 at all angles of arrival. This analysis assumes peak antenna gain and is thus valid for all vehicle attitude states. Further, the onboard radio power may be adjusted to further reduce power as required to mitigate interference.

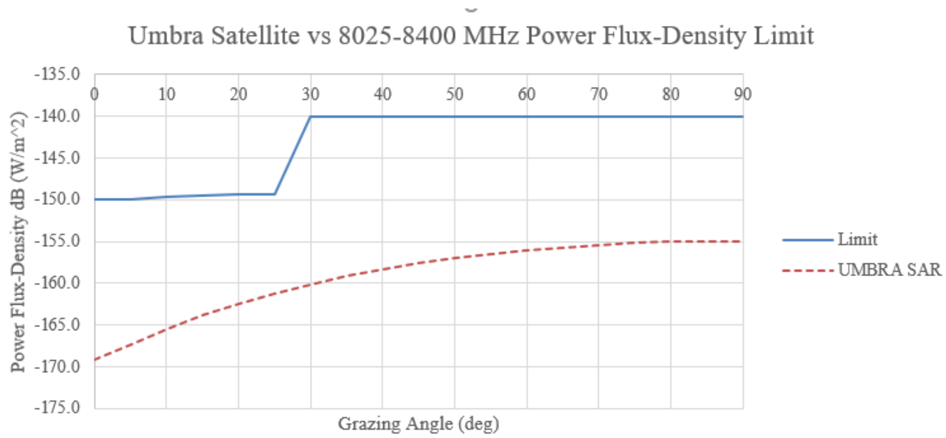
Figure 9. Nominal Power Flux Density for S-Band (2200-2290 MHz)



5.2. Power Flux Density in the band 8025-8400 MHz

To ensure that interference with any Deep Space Research communications within the adjacent frequency spectrum at 8400-8450 MHz remains below -221 dB(W/(m^2 Hz)), per ITU-R SA.1157-1, Umbra plans to operate such that the highest band edge within the operating frequency (8250 MHz) is at least 125-MHz below the lower edge of the DSN band. Figure 10 shows power flux density for the band plotted against the ITU limit.

Figure 10. Nominal Power Flux Density for X-Band (8025-8275 MHz)

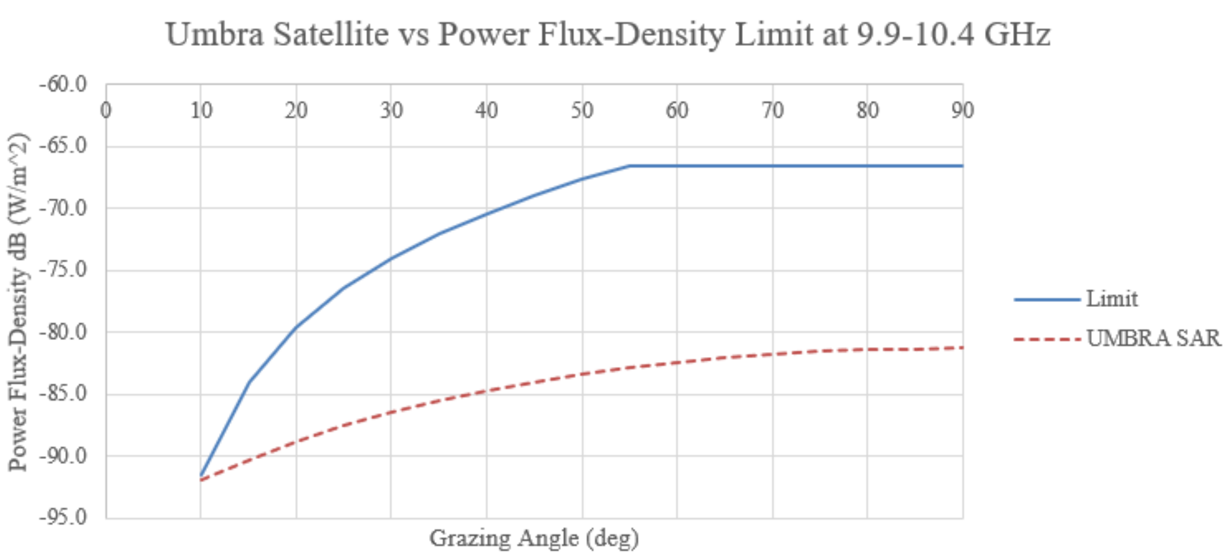


5.3. Power Flux Density in the band 9900-10400 MHz

PFD limits between 9900 - 10400 MHz are identified in Table 21-4 in ITU Radio Regulation 21.16, which was adopted in WRC-15. Figure 11 shows the simulated worst-case PFD compared to the allowable limits.

Umbra plans to operate at grazing angles greater than 10 degrees.

Figure 11. Power Flux Density for X-Band (9.9-10.4 GHz)



ITU limits per Section 5, Table 21.47

5.4. Power Flux Density at the Geostationary Satellite Orbit

No. 22.5 of the ITU Radio Regulations specifies that in the frequency band 8025-8400 MHz, which the EESS (using non-geostationary satellites) shares with the fixed-satellite service (Earth-to-space) and the meteorological-satellite service (Earth-to-space), the maximum power flux-density produced at the geostationary satellite orbit ("GSO") by any EESS space station shall not exceed –174 dBW/m^2 in any 4 kHz band.

The calculation below shows that the PFD produced by the transmissions from the proposed Umbra satellites does not exceed the limit in No. 22.5, even in the worst possible hypothetical case.

The PFD at the GSO produced by the satellite transmission is:

PFD [dBW/m^2 /4 kHz] = EIRP (dBW) - 71 - 20log10(D) - 10log10(BW) – 24

Where:

EIRP is the maximum EIRP of the transmission, in dBW;

- D is distance between the satellite and GSO, in km;
- BW is the signal bandwidth of the transmission, in MHz.
- The minimum possible distance between the satellite and the GSO is 35,786 - 600 = 35,186 km.

Under a hypothetical assumption that an Umbra satellite antenna is radiating at its peak EIRP toward the GSO, with the peak EIRP = 18 dBW and BW = 250 MHz produces a PFD at the GSO of:

-192 dBW/m^2/4 kHz.

Even in this worst-case scenario the PFD is 17 dB below the specified maximum.

5.5. Protection of Terrestrial Radar and Radiolocation Beacons

Footnote 5.427 of the ITU and U.S. Table of Frequency Allocations specifies that responses from EESS radar transponders not be confused with responses from radar beacons and prohibits responses from radar transponders from causing harmful interference to ship or aeronautical radars.[2] Umbra's satellites will not operate as radar transponders. Accordingly, this footnote is not applicable.

Moreover, Umbra's SAR transmissions in this band will not themselves be confused with radar or radiolocation beacons due to the fundamentally different timing, duration, and other characteristics of radar beacon signals compared to Umbra's SAR transmissions. For these same reasons, with respect to footnote 5.474D, Umbra's transmissions will not cause harmful interference to ship or aeronautical radars or beacons in the radionavigation (9200-9300 MHz) or radiolocation service (10.0-10.4 GHz).

5.6. Compliance with applicable ITU notes for 9200-9300 MHz and 9900-10400 MHz frequency bands

5.6.1. Note 5.474A: The use of the frequency bands 9200-9300 MHz and 9900-10400 MHz by the Earth exploration-satellite service (active) is limited to systems requiring necessary bandwidth greater than 600 MHz that cannot be fully accommodated within the frequency band 9300-9900 MHz.[3] Umbra satellites require necessary bandwidth greater than 600

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[2] *See* 47 C.F.R. § 2.106 n.5.427.

[3] Such use is subject to agreement to be obtained under No. 9.21 from Algeria, Saudi Arabia, Bahrain, Egypt, Indonesia, Iran (Islamic Republic of), Lebanon and Tunisia. An administration that has not replied under No. 9.52 is considered as not having agreed to the coordination request. In this case, the notifying administration of the satellite system operating in the Earth exploration-satellite service (active) may request the assistance of the Bureau under Sub-Section IID of Article 9. (WRC-15).

MHz as stated and is committed to obtaining agreements for coordination under No. 9.21 and will work with the Bureau to do so if necessary.

5.6.2. Note 5.474B: Stations operating in the Earth exploration-satellite (active) service shall comply with Recommendation ITU-R RS.2066-0 (WRC-15). As described below, no RAS sites will be imaged without prior coordination. *See infra* Section 6.7.

5.6.3. Note 5.474C: Stations operating in the Earth exploration-satellite (active) service shall comply with Recommendation ITU-R RS.2065-0 (WRC-15). As described below, interference in bands from 8400 MHz to 8500 MHz is not possible. *See infra* Section 6.5.

5.6.4. Note 5.474D: Stations in the Earth exploration-satellite service (active) shall not cause harmful interference to, or claim protection from, stations of the maritime radionavigation and radiolocation services in the frequency band 9200-9300 MHz, the radionavigation and radiolocation services in the frequency band 9900-10 000 MHz and the radiolocation service in the frequency band 10.0-10.4 GHz. (WRC-15) As described above, interference with maritime radionavigation and radiolocation is not possible. *See supra* Section 5.5.

5.6.5. Note 5.427: In the 9300-9500 MHz band, the response from radar transponders shall not be capable of being confused with the response from radar beacons (racons) and shall not cause interference to ship or aeronautical radars in the radionavigation service, having regard, however, to No. 4.9. Umbra does not operate radar transponders and therefore this note is not applicable.

5.6.6. Note 5.475A: The use of the band 9300-9500 MHz by the Earth exploration-satellite service (active) and the space research service (active) is limited to systems requiring necessary bandwidth greater than 300 MHz that cannot be fully accommodated within the 9500-9800 MHz band. (WRC-07). Umbra requires bandwidth greater than 300 MHz to operate its SAR payload.

6. INTERFERENCE ANALYSIS

6.1. S-Band Downlink (2200-2290 MHz)

The 2200-2290 MHz band is allocated for Federal use for EESS (Earth-to-space) subject to such conditions as may be applied on a case-by-case basis. Further, transmissions from the satellites operating in this band shall not cause harmful interference to Federal and non-Federal stations operating in accordance with the U.S. Table of Frequency Allocations.

Umbra understands that use and coordination of this band may not be possible for its earth station locations within the United States. It is not seeking approval for such earth stations. Umbra selected this band after a review of alternatives due to operational needs, available hardware, and compatibility with third-party commercial earth station operators.

Interference between Umbra satellites and other systems is unlikely because EESS systems operating in the 2200-2290 MHz band normally transmit only in short periods of time while visible from the dedicated receiving earth stations (typically less than 10 minutes for a single pass). Further, the earth station beam required to intercept the transmitted signal is highly directive. Further, Umbra satellites will use only 100 kHz of bandwidth. Each satellite will be configured so as not to exceed the PFD limit (see section 5 of this Technical Attachment) for non-federal space stations.

For interference to happen, satellites belonging to different systems would have to travel through the antenna beam of the receiving earth station and transmit at the same time and at the same frequency. In such a very unlikely event, interference can still be avoided by coordinating the satellite transmissions so that they do not occur simultaneously.

In addition, orbital parameters can also be adjusted such that phasing of the contacts can be offset over time. The satellite is equipped with a propulsion system which will allow additional maneuverability and phasing throughout their life.

6.2. X-Band Downlink (8025-8400 MHz)

As described in the table below, Umbra will utilize X-Band within the 8025-8400 MHz band for high bandwidth mission data downlink. Umbra X-Band data downlink will operate at the lower end of the band occupying 250 MHz from 8025-8275 MHz with a maximum EIRP of 23.2 dBW using RHCP polarization.

Umbra has performed analysis showing that required interference mitigation and power flux density requirements are met.

Table 7. Payload downlink characteristics

Frequency Range	8025-8400 MHz
Bandwidth	250 MHz
Center Frequency	8150 MHz
EIRP	< 25 dBW
Polarization	RHCP

Umbra will exercise mitigation techniques outlined in the ECC Report 115, for operating its satellite downlink in the 8025 - 8400 MHz band.[4] Below are the key steps taken to minimize risk of interference.

- Satellites will operate in a non-broadcast mode, only radiating when transmitting data to one or more of the planned earth stations;
- Satellites will employ a directional antenna;

[4] *See* Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administration (CEPT), Use of the Frequency Band 8025-8400 MHz by EESS, ECC Report 115 (Ljubljana, January 2008).

- Satellites will operate well within the power flux density limits for all emissions; and
- Satellites will operate in the lower portion of the 8025 – 8400 MHz band.

6.3. Interference Between EESS Systems Operating in the band 8025-8400 MHz

Interference between Umbra satellites and those of other systems is unlikely because EESS systems operating in the 8025-8400 MHz band normally transmit only in short periods of time while visible from the dedicated receiving earth stations (typically less than 10 minutes for a single pass).

The satellites are designed to operate in non-broadcast mode. For interference to happen, satellites belonging to different systems would have to travel through the antenna beam of the receiving earth station and transmit at the same time and at same frequency. In such a very unlikely event, interference can still be avoided by coordinating the satellite transmissions so that they do not occur simultaneously. This frequency coordination is managed by the commercial operator that controls the earth stations.

In addition, orbital parameters can also be adjusted such that phasing of the contacts can be offset over time. The satellite is equipped with a propulsion system which will allow additional maneuverability and phasing throughout their life.

6.4. Interference with the Fixed Service and the FSS in the band 8025-8400 MHz

Umbra demonstrates that the Satellite will meet the limits specified by the ITU for protection of geostationary FSS satellites in the 8025-8400 MHz band. *See supra* Section 5.4.

6.5. Protection of the Deep Space Research in the Band 8400-8450 MHz

Umbra will use the lower 250 MHz of the 8025-8400 MHz band, leaving a guard band of 125 MHz to protect the 8400-8450 MHz band as well as using a directive antenna as shown in Section 3.1 Further, Umbra utilizes a programmable digital filter and hardware filter on our X-band radio to ensure that these transmissions are always in compliance with ITU out-of-band emissions recommendations. Umbra satellites will not be intentionally commanded to transmit unless the main beam is oriented towards a licensed earth station.

6.6. X-Band Radar (9200-10400 MHz)

Umbra demonstrates that the Satellite will meet the limits specified by the ITU for protection of the Fixed Satellite Service in the 9900 - 10400 MHz band. *See supra* Section 5.3.

6.7. Protection of the Radio Astronomy Service in the Frequency Band 10.6-10.7 GHz

The ITU Recommendation RS.2066-0 provides an operational procedure to avoid main-beam to main-beam coupling between EESS (active) SAR systems when transmitting near 9600 MHz and radio astronomy service (RAS) stations performing observations in the band 10.6-10.7 GHz in order to avoid damage to the sensitive RAS low noise amplifier.

In accordance with this recommendation Umbra will:

- Establish geographic exclusion zones around RAS sites, e.g. all RAS sites listed in ITU-R RS.2066-0.
- Operate using a 9600 MHz center frequency when bandwidth requirements do not exceed 600 MHz.
- Coordinate with RAS operators prior to illumination.

7. COORDINATION WITH U.S. GOVERNMENT SYSTEMS

There are a variety of federal allocations in the bands proposed to be used by the Umbra SAR Constellation. Umbra has provided various U.S. government operators information on the operational parameters of its system and is committed to successful coordination with all relevant government satellite and terrestrial networks. Umbra is confident that the characteristics of its proposed system will facilitate an operational approach that will allow Umbra to share this spectrum with government systems without harmful interference.

8. ORBITAL DEBRIS MITIGATION

Umbra has incorporated the material objectives set forth in this application into the technical specifications established for design and operation of its NGSO system. Umbra has internally reviewed orbit debris mitigation requirements and has incorporated them, as appropriate, into its operational plans. *See also* attached Orbital Debris Assessment Report (ODAR).

8.1. SPACECRAFT HARDWARE DESIGN

According to an analysis done by Umbra, no debris is released during normal operations. Umbra is also aware of the possibility that its system could become a source of debris in the unlikely event of a collision with small debris or meteoroids that could either create jetsam or cause loss of control of the spacecraft and prevent post-mission disposal. Umbra has assessed the probability of collision using NASA's Debris Assessment Software (DAS v.3.1.2) and is compliant with every applicable NASA standard.

Umbra satellites include on-board propulsion systems, which will be used to actively reduce the probability of collision with other known objects. Umbra will be working with CSpOC on monitoring collision probability for its systems and is planning collision avoidance proof of concept with UMBRA-2001. Umbra has completed an ODAR report for the planned satellites described in this application, which is attached as an appendix to this application.

Umbra incorporates redundancy, shielding, separation of components, and other physical characteristics into the satellites' design. The propulsion system will contain 5 kg of water as propellant. Umbra spacecraft will not expel any other matter besides the water used as fuel during thrust events. Thus, there is no source of debris from operation of the propulsion system.

8.2. MINIMIZING ACCIDENTAL EXPLOSIONS

Umbra is designing its spacecraft in a manner that limits the probability of accidental explosion. Umbra has assessed the possibility of accidental explosions during and after completion of mission operations through a failure mode verification analysis. As part of the satellite manufacturing process, Umbra has taken steps to ensure that debris generation will not result from the conversion of energy sources onboard the Umbra satellites into energy that fragments the satellites. The only areas of the spacecraft that will store any significant amount of energy are its batteries and pressurant tank used for propulsion.

These sources of energy will be depleted or safely contained when they are no longer required for mission operations or to accomplish post-mission disposal, further minimizing risk. The tanks are designed to contain up to 5 kg of water. The worst case on-orbit tank pressure for a full tank is 40 psia at 45°C. The tank temperature is not expected to exceed 35°C on orbit. The tanks have been designed and tested for a burst pressure of 325 psi. There is a 225% margin on the tank's burst pressure, ensuring that there is no risk of accidental explosion of the propulsion system.

8.3. SAFE FLIGHT PROFILES

Through detailed mission planning, Umbra has carefully assessed and limited the probability of its system becoming a source of debris by collisions with large debris or other operational space stations. DAS analysis shows that the probability of collision with a large object is 0.0001, which is well below the 0.001 requirement. Umbra will be continuously coordinating with CSpOC through their existing conjunction reporting database to proactively address conjunction alerts. We will engage with any operators of nearby constellations or space stations, as necessary, to ensure safe and coordinated space operations. Umbra will be proactive in mitigating any risks from its de-orbiting satellites to inhabitable orbiting objects, including, for example, the International Space Station. Through these measures, Umbra will be able to avoid collisions on an ongoing basis.

Umbra confirms that it intends to perform collision avoidance procedures, including conjunction assessment, execution of avoidance maneuvers, trajectory planning and conjunction assessment, and notification to other potentially affected operators of any significant planned alteration of a satellite's trajectory for all phases of operations. Umbra certifies that upon receipt of a space situational awareness conjunction warning, it will review and take all possible steps to assess the collision risk and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk may include but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

Prior to deployment, Umbra will register all satellites with the 18th Space Control Squadron (or a successor entity). Following deployment, Umbra will identify and track its satellites using a network of ground stations that will establish contact with the satellites. Umbra certifies that each of its space stations will have a unique telemetry marker allowing it to be distinguished from other satellites or space objects. Because Umbra satellites will be larger than 10 cm in their smallest dimension, they are presumed to be trackable.

Umbra routinely performs precise orbit determination and orbit prediction and will provide that information to the 18th Space Control Squadron (or a successor entity) or other satellite operators to aid collision avoidance response, including conjunction assessment and maneuver planning. Umbra plans to share information regarding initial deployment, ephemeris, and significant planned maneuvers with the 18th Space Control Squadron (or a successor entity) and other entities that engage in space situational awareness or space traffic management functions.

8.4. SAFETY OF FLIGHT CONTINGENCY OPERATIONS

While preparations can be made to help assure that there will never be a fault on orbit it is not reasonable to take on Class A levels of mission assurance and adhere to the company's mission of providing low-cost, high quality, SAR data products. The resulting requirement is to create a balance between reasonable measures of redundancy with the ability to recover if a fault occurs onboard or from one of the ground stations beyond our control. From the very first orbit and throughout the intended mission life Umbra has arranged to assure that at least once per orbit there is an opportunity to communicate with one of our ground stations and receive new tasking. If through one of the aforementioned faults, should Umbra satellites exceed a configurable threshold for the number of minutes (orbits) exceeded without contact from the ground station network the satellites have the ability to attempt to autonomously re-connect with our ground terminals located outside the US over our TT&C channel. This approach has been discussed in pre-coordination with federal operators for our experimental license application.

9. POST-MISSION DISPOSAL

Each satellite in the Umbra SAR Constellation is designed for a useful lifetime of five years, at the end of which Umbra intends to dispose of satellites through atmospheric re-entry. Nominally, to avoid interaction with LEO assets as well as to accelerate reentry, a Post-mission Disposal (PMD) maneuver to lower the orbit to 515 x 380 km will be performed in conjunction an End-of-mission (EOM) maneuver orienting the z-axis with the velocity vector. This orientation is also the most stable equilibrium orientation that the spacecraft would naturally assume thereby accelerating the deorbit of a non-functional satellite without any external input. Once we have completed the PMD / EOM maneuver sequence the Umbra satellites are expected to re-enter the atmosphere within 0.2-0.4 years. We anticipate beginning these operations once the system passes five years of on-orbit operations to assure compliance with the streamlined rule of six years.

Umbra has conducted a preliminary re-entry risk analysis using DAS. The spacecraft was modeled to a level of fidelity that included all major components. As modeled, DAS indicates the entire satellite will burn up during uncontrolled re-entry with a zero casualty area as required. Accordingly, the risk of human casualty on the ground from Umbra satellites re-entering the atmosphere is 1:100000000, which is the lowest reportable value from DAS.

ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application, and that it is complete and accurate to the best of my knowledge and belief.

UMBRA LAB, INC.

By: /s/ Alex Potter

Alex Potter

Director of Payloads

UMBRA LAB, INC.

Dated: June 16, 2021