**EXHIBIT A - TECHNICAL ATTACHMENT**

**TABLE OF CONTENTS**

## 1. SCOPE AND PURPOSE

In support of the Application, this Technical 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 two (2) non-geostationary orbit ("NGSO") satellites (the "Umbra Block Two Constellation").

### 2.1. Orbital Information

The satellites will include a water-based propulsion system and, through regular corrective propulsive maneuvers by Umbra, are anticipated to remain in their planned orbit range given below. Representative orbital information is provided in the Schedule S.

**Table 1. Orbital Parameters**

| **Parameter** | **Value** |
|---|---|
| Satellites per Plane | 2 |
| Inclination | 97.4 ± 0.1 ° |
| Orbital Period | 5689 ± 37 sec |
| Operating Altitude Range (Apogee and Perigee) | 535 ± 30 km |
| Argument of Perigee | N/A |
| Nominal Mean Equatorial Orbit Altitude | Near Circular (535 km) |
| Active Service Arc | Full Orbit |

The satellites are scheduled for launch on a SpaceX Transporter-9 rideshare mission and, as such, Umbra has no control regarding the exact right ascension of the ascending node ("RAAN") values for the plane. SpaceX will provide the RAAN values approximately two months prior to launch. SpaceX has confirmed that Umbra's deployment altitude for the Transporter-9 launch will be 500 ± 20 km, which is reflected in this Application.

### 2.2. Spectrum

The Umbra Block Two Constellation will operate in the frequency bands shown in Table 2.

**Table 2. Frequencies of Operation**

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

### 2.3. Technology and Operations

The satellites will meet all applicable power flux density ("PFD") and other coexistence requirements even in a worst-case configuration, as discussed below.[2] 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.[3] Umbra previously

[1] The center frequencies for the TT&C and data links are representative and may change based on coordination with Federal operators and other users.

[2] *See infra* Section 5.

[3] *See infra* Section 6.

conducted an extensive analysis of non-interference for wide-band SAR operations and was granted a waiver of the U.S. Table of Frequency Allocations for those operations under the License.[4]

### 2.4. Ground Station Locations

As stated in the Narrative, Umbra intends to utilize the ground stations of the Commercial RGTs network listed in

Table ***3*** below, subject to coordination with Federal spectrum managers for all commercial ground station use. Umbra plans to use both X-Band downlink and S-Band uplink and downlink to communicate with these commercial ground stations, as well as with Federal ground stations.[5] As indicated in Table 4, Umbra will only communicate through X-Band downlink and S-Band uplink with U.S.-based Commercial RGTs.

**Table 3. International Commercial Ground Sites Requested (S-Band and X-Band)**

| | |
|---|---|
| Svalbard, Norway | Seoul, South Korea |
| Nemea, Greece | Sydney, Australia |
| Punta Arenas, Chile | Troll, Antarctica |
| Awarua, New Zealand | Mingenew, Australia |
| Dublin, Ireland | Hartebeesthoek, South Africa |
| Vasteras, Sweden | Jeju Island, South Korea |
| Zallaq, Bahrain | Baie Jacotet, Mauritius |
| Cape Town, South Africa | |

[4] *See* Stamp Grant, Umbra Lab, Inc., IBFS File No. SAT-MOD-20220627-00065; SAT-AMD-20220926-00127 (granted Dec. 1, 2022) (the “License”); *see also* Exhibit C - Interference Analysis for the Umbra Block Two Constellation (providing updated interference analysis to include 8 SAR satellites).

[5] Use of S-Band downlink to communicate with Federal ground stations in the U.S. will be subject to the Commission's favorable grant of Umbra's request for waiver of the U.S. Table of Frequency Allocations, to the extent necessary, to utilize S-Band downlink in support of its Federal customers. *See supra* Narrative, Section IV.A.

**Table 4. Domestic Commercial Ground Sites Requested (except S-Band downlink)**

| | |
|---|---|
| Fairbanks, USA | Portland, USA |
| Honolulu, USA | Columbus, USA |
| Long Beach, USA | Barrow, Alaska |

## 3. Predicted Space Station Antenna Gain Patterns and Contours

Space stations in the Umbra Block Two 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 using the spectrum allocations shown in Table 2 above with the gain patterns shown in Figure 1 below. The Block Two Constellation will operate using X-Band communications by means of a patch antenna, as depicted below in Figure 1 and Figure 2.

**Figure 1. Umbra X-Band Downlink Gain Pattern (4x4)**

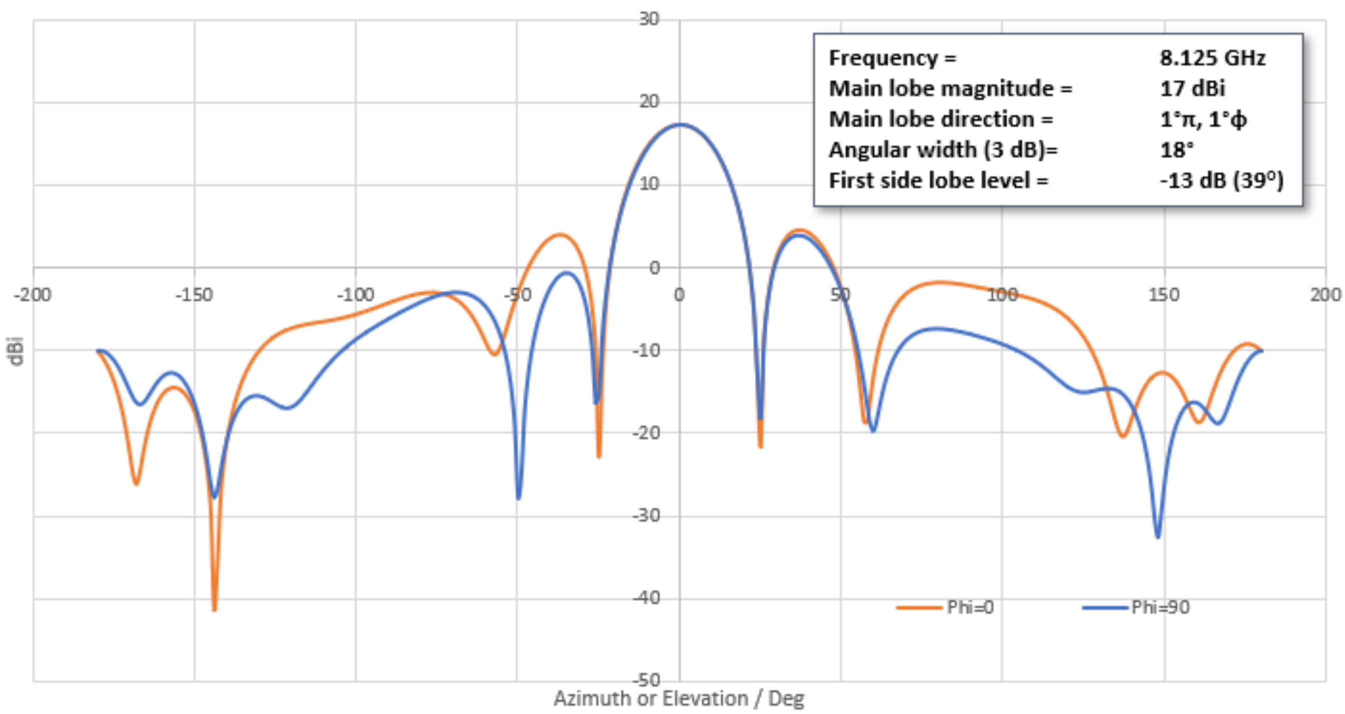
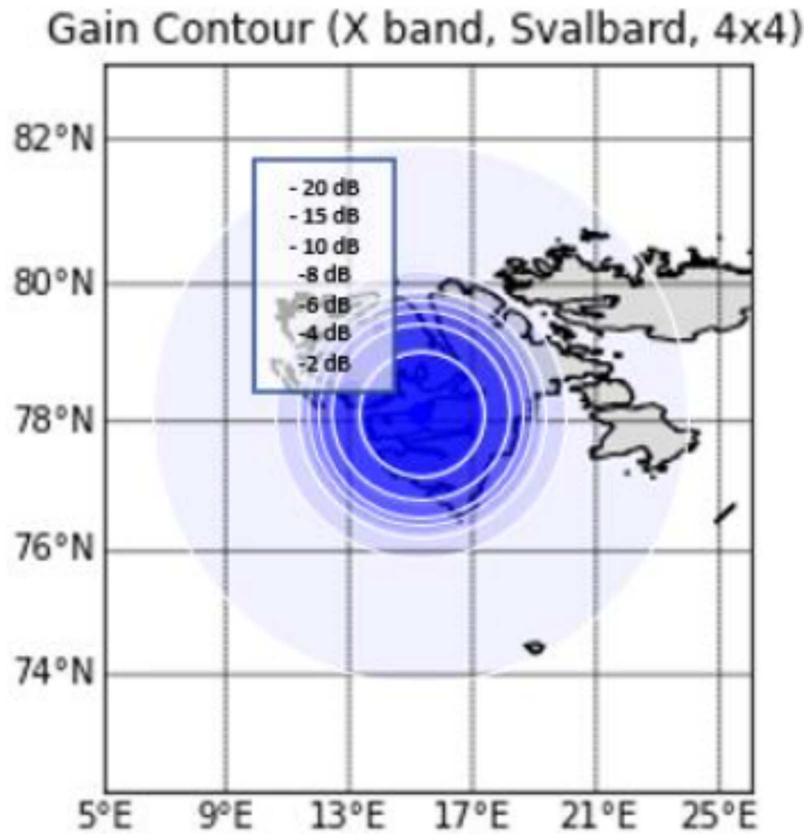


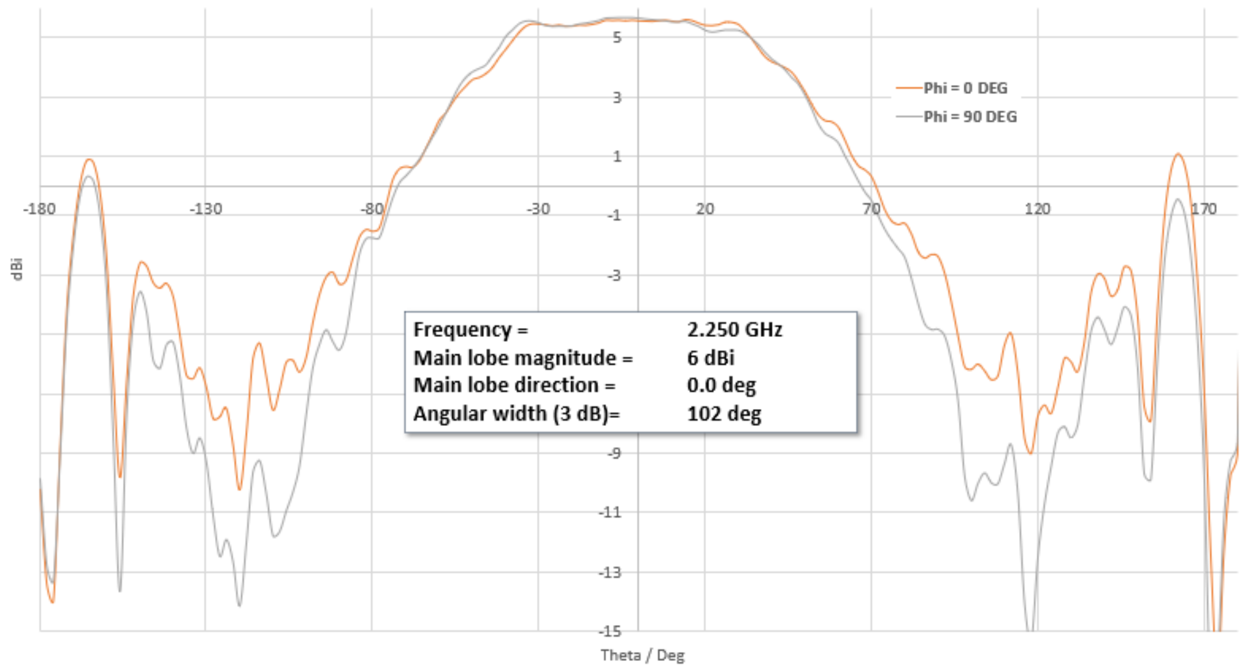
**Figure 2. Umbra X-Band Gain Contours (Svalbard, 4x4)**




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

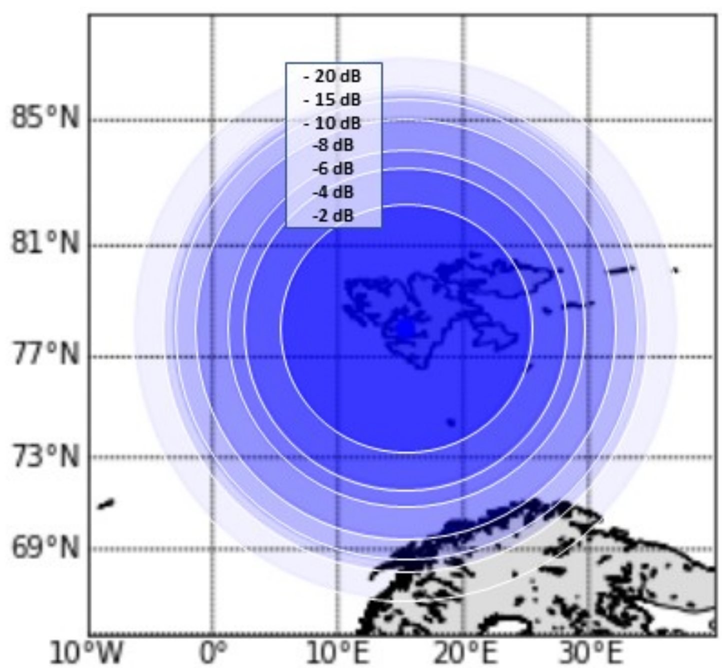
The S-Band TT&C downlink beam will have a maximum EIRP of –9 dBW in a 100 kHz channel centered at 2254 with RHCP and LHCP polarization (Band 1 and Band 2, respectively) with the gain patterns shown in Figure 3 and the gain contours in Figure 4 below.

**Figure 3. Umbra S-Band TT&C Downlink Gain Pattern***




*Vendor supplied antenna test data.

**Figure 4. Umbra Maximum Footprint S-Band Gain Contours (Svalbard)**

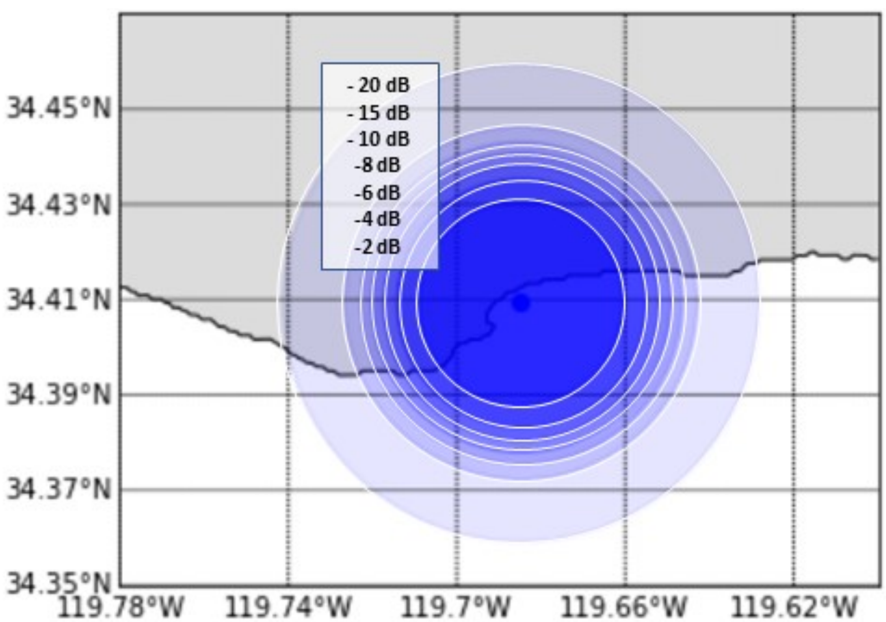


### 3.3. X-Band SAR Antenna

The X-Band SAR beam will have a maximum EIRP of 78.2 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 5 and the gain contours in Figure 6 below.

**Figure 5. Umbra X-Band SAR Gain Pattern**


**Figure 6. 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 definite cessation of emissions from the satellites, as required by Section 25.207 of the Commission's rules.

## 5. COMPLIANCE WITH PFD LIMITS AND OTHER SHARING CRITERIA

This section demonstrates that the 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. Umbra may continue to leverage the SAR-sensing capabilities of its systems throughout the deorbiting process to a mean altitude of no lower than 450 km. Therefore, all worst-case PFD analyses below are calculated at an operational altitude of 450 km for sustained SAR operations and X-band communications during deorbit PMD operations.

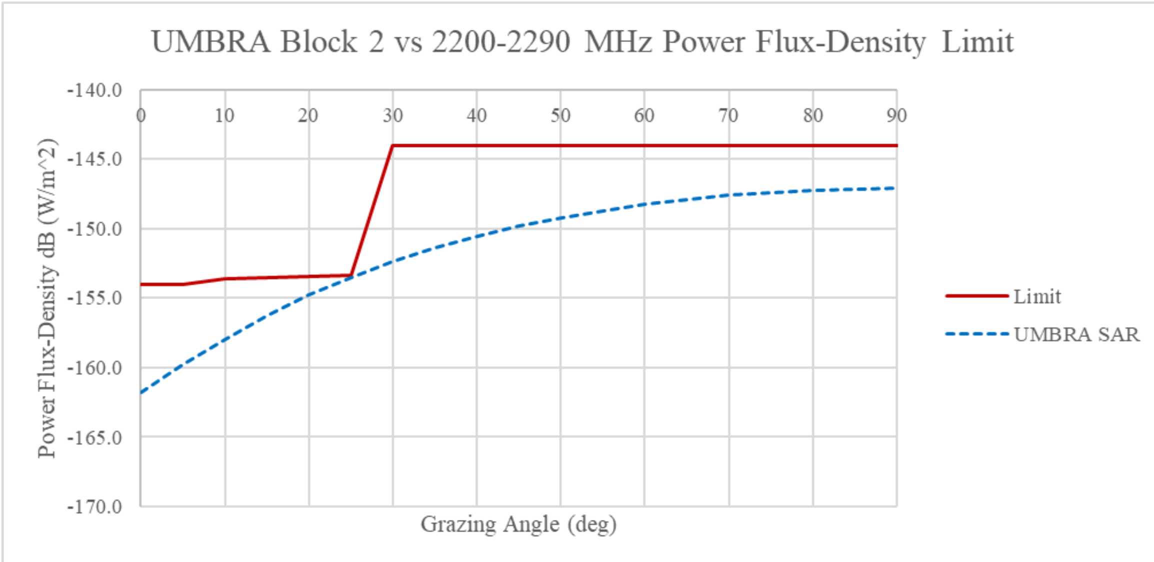
### 5.1. Power Flux Density in the Band 2200–2290 MHz

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.[6] Further, following the PMD maneuver at the end of the satellites' useful lifetime, the EIRP of this communications channel will remain compliant with PFD limits as shown in Figure 7 throughout deorbit operations.

Figure **7. Nominal Power Flux Density for S-Band (2200–2290 MHz)**7 shows that each satellite complies with the PFD limit 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.

[6] 47 C.F.R. § 2.106 n.US303.

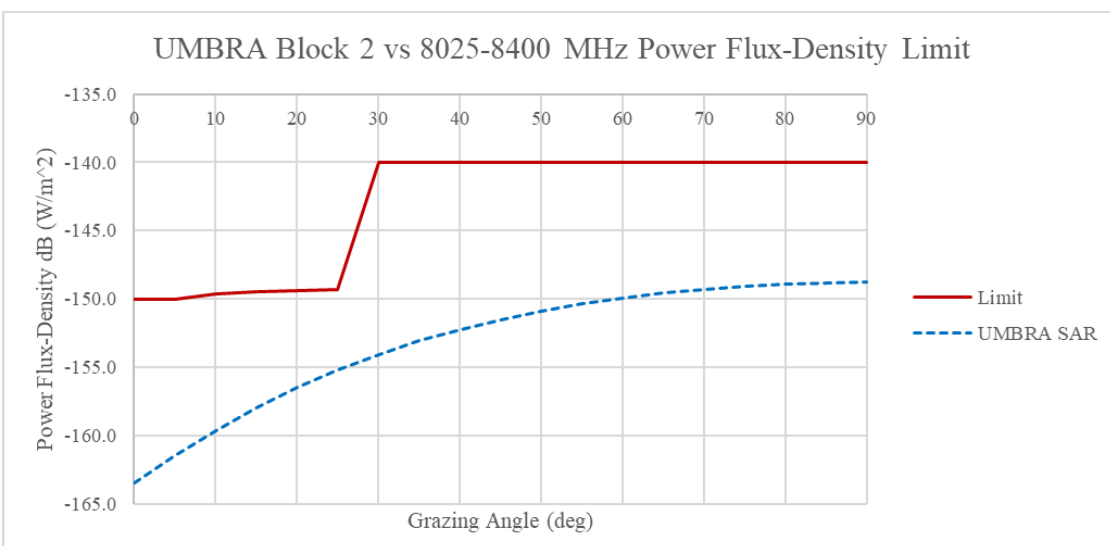
**Figure 7. Nominal Power Flux Density for S-Band (2200–2290 MHz)**




### 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 frequencies (8300 MHz) is at least 100-MHz below the lower edge of the DSR band. Figure 8 shows PFD for X-band communications at 450 km altitude plotted against the ITU limit, demonstrating that this channel will never exceed the recommended limits.

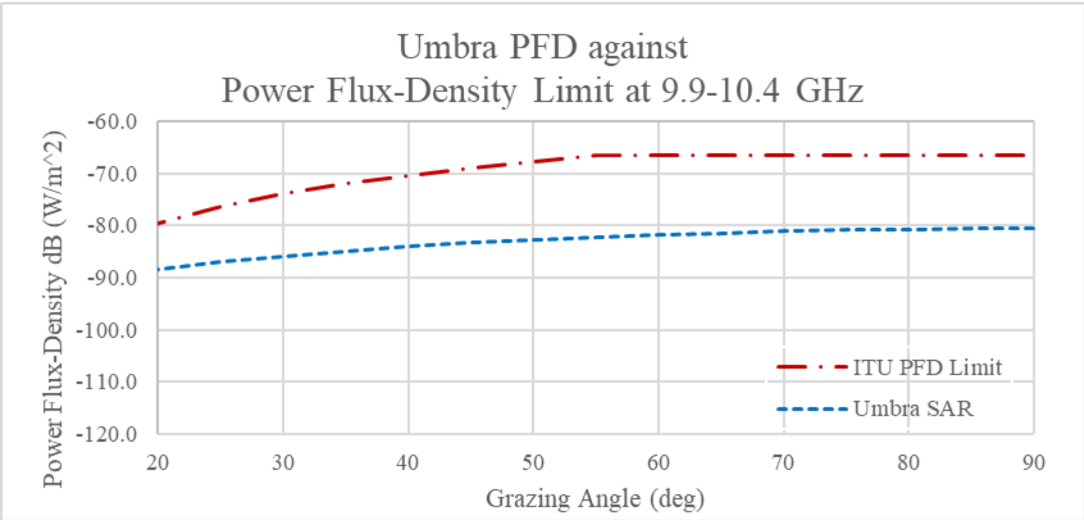
**Figure 8. Nominal Power Flux Density for X-Band Transmission**



### 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 Section 21.16.[7] Figure 9 shows the simulated worst-case PFD for all possible collection angles (nominally at 20-70 degree grazing) compared to the allowable limits.

**Figure 9. 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

Section 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 PFD produced at the geostationary satellite orbit ("GSO") by any EESS space station shall not exceed –174 dBW/m$^2$ in any 4 kHz band.[8] The calculation below shows that the PFD produced by the transmissions from the proposed satellites

[7] ITU Radio Regulations, Vol. 1: Articles, Art. 21 § 21.16, at 283, Table 21-4 (2020).

[8] ITU Radio Regulations, Vol. 1: Articles, Art. 22 § 22.5, at 281 (2020).

does not exceed the limit in Section 22.5, even in the worst possible hypothetical case. The PFD at the GSO produced by the satellite transmission is:

$$PFD\left[\frac{dBW}{m^2 \cdot 4\,kHz}\right] = EIRP\,[dBW] - 71 - 20\log_{10} D - 10\log_{10} BW - 24$$

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 $35{,}786 - 565 = 35{,}221\ km$ .

Under a hypothetical assumption that an Umbra satellite antenna is radiating at its peak EIRP toward the GSO, with the peak $EIRP = 23.2\ dBW$ and $BW = 250\ MHz$ produces a PFD at the GSO of

$$-276.7\ \frac{dBW}{m2 \cdot 4kHz}$$

Even in this worst-case scenario, the PFD is well 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 are not to be confused with responses from radar beacons and prohibits responses from radar transponders from causing harmful interference to ship or aeronautical radars.[9] Umbra's satellites will not operate as radar transponders nor will Umbra's SAR transmissions in this band 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. Accordingly, this footnote is not applicable.

### 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 EESS (active) is limited to systems requiring necessary bandwidth greater than 600 MHz that

[9] *See* 47 C.F.R. § 2.106 n.5.427.

cannot be fully accommodated within the frequency band 9300–9900 MHz.[10] Umbra satellites require necessary bandwidth greater than 600 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 EESS (active) shall comply with Recommendation ITU-R RS.2066-0 (WRC-15). As described below, no RAS sites will be imaged without prior coordination.[11]

**5.6.3. Note 5.474C**: Stations operating in the EESS (active) 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.[12]

**5.6.4. Note 5.474D**: Stations in the EESS (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.[13] For additional information, please see applicable interference analysis provided in Exhibit C.[14]

**5.6.5. Note 5.475A**: The use of the band 9300–9500 MHz by the EESS (active) and the space research service (active) is limited to systems requiring necessary bandwidth greater than 300 MHz

[10] 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).

[11] *See infra* Section 6.7

[12] *See infra* Section 6.5.

[13] *See supra* Section 5.5.

[14] *See* Exhibit C - Interference Analysis.

that cannot be fully accommodated within the 9500–9800 MHz band.[15] Umbra requires bandwidth greater than 300 MHz to operate its SAR payload. Accordingly, use of the 9300–9500 MHz band is appropriate.

**5.6.6. Note 5.476A and 5.478B**: Umbra transmissions have different waveforms, short transmission, and very low duty cycle, and thus are extremely unlikely to interfere with radionavigation and radiolocation services in the 9300-9800 MHz band, or stations of the fixed service in the 9800-9900 MHz band. Further, radionavigation, radiolocation, and signals from stations of the fixed service cannot be confused with Umbra's transmissions due to the fundamentally different timing, duration, and other characteristics of such signals compared to Umbra's SAR transmissions. Similar to how our system's analog and digital filtering prevents transmissions from these services from having an impact on the formation of SAR images, systems on the ground are similarly protected and as such are unlikely to suffer from interference from Umbra transmissions, so long as Umbra transmissions comply with PFD limits. Even in the highly unlikely case where one of these stations had no digital filtering, Umbra's transmissions to any point on Earth are so short and utilize such a low duty cycle that the impact would be rare and inconsequential. Accordingly, Umbra complies with footnotes 5.476A and 5.478B.

**5.6.7. Note 5.478A**: The use of the band 9800–9900 MHz by the EESS (active) and the space research service (active) is limited to systems requiring necessary bandwidth greater than 500 MHz that cannot be fully accommodated within the 9300–9800 MHz band.[16] Umbra's SAR transmissions require more than 500 MHz of bandwidth. Accordingly, use of the 9800–9900 MHz band is appropriate.

**5.6.8. Note 5.427**: As discussed in Section 5.5 above**,** Umbra's satellites will not operate as radar transponders, therefore, this note is not applicable.[17]

## 6. INTERFERENCE ANALYSIS

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

Umbra plans to transmit over S-band downlink to commercial earth stations outside of the U.S. and requests appropriate waiver in this Application to also communicate over S-band downlink with Federal

---

[15] 47 C.F.R. § 2.106 n. 5.475A

[16] *Id.* at n. 5.478A.

[17] *See supra* Section 5.5.

ground stations.[18] Umbra selected this band after a review of alternatives due to operational needs, available hardware, and compatibility with third-party commercial earth station operators.

As described in the table below, the Umbra S-Band TT&C Downlink will operate within the 2200–2290 MHz band with a maximum EIRP of –9 dBW in a 100 kHz channel centered at 2254 MHz using RHCP polarization and LHCP polarization.[19]

**Table 4. TT&C Downlink Characteristics**

| | |
|---|---|
| **Frequency Ranges** | 2200-2290 MHz |
| **Bandwidth** | 100 kHz |
| **Center Frequency** | 2254 MHz at RHCP and LHCP |
| **EIRP** | -9 dBW (maximum) |

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 and Umbra satellites will only use up to 0.1 MHz of bandwidth. Each satellite will also be configured so as not to exceed the PFD limit for non-Federal space stations.[20] Therefore, spectrum sharing in this band is possible and Umbra's operations will not cause harmful interference to other operators.[21]

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

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

[18] *See supra* Narrative, Section IV.A.

[19] These are representative channels. The use of this frequency band is subject to coordination with Federal operators and the specific channels may change as a result.

[20] *See supra* Section 5.1.

[21] *See supra* Narrative, Section III.A.

8150 MHz using RHCP and LHCP polarization.[22] Umbra has performed analysis showing that required interference mitigation and PFD requirements are met.[23]

**Table 5. X-Band Mission Data Downlink Characteristics**

| | |
|---|---|
| **Frequency Range** | 8025–8275 MHz |
| **Bandwidth** | 250 MHz |
| **Center Frequency** | "Band 1" - 8150 MHz<br>"Band 2" - 8150 MHz |
| **EIRP** | < 23.2 dBW |
| **Polarization** | "Band 1" - RHCP<br>"Band 2" - LHCP |

Umbra will exercise mitigation techniques outlined in the ECC Report 115 for operating its satellite downlink in the 8025–8400 MHz band.[24] 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;
- Satellites will operate well within the PFD 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).

Umbra's 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

---

[22] This is a representative channel. The use of this frequency band is subject to coordination with Federal operators and the specific channel may change as a result.

[23] *See supra* Section 5.2.

[24] *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).

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 with the respective operators so that they do not occur simultaneously. In addition, orbital parameters can be adjusted such that phasing of the contacts can be offset over time.

### 6.4. Interference with the Fixed Service and the FSS in the Band 8025–8400 MHz

Umbra demonstrates that the satellites will meet the limits specified by the ITU for protection of geostationary fixed satellite service ("FSS") satellites in the 8025–8400 MHz band.[25]

### 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. The 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 satellites will meet the limits specified by the ITU for protection of the FSS in the 9900–10400 MHz band.[26]

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

To avoid damage to sensitive radio astronomy service ("RAS") low noise amplifiers, ITU Recommendation RS.2066-0 provides an operational procedure to avoid main-beam to main-beam

---

[25] *See supra* Section 5.4.

[26] *See supra* Section 5.3.

coupling between EESS (active) SAR systems transmitting near 9600 MHz and RAS stations performing observations in the 10.6–10.7 GHz band.[27]

In accordance with this Recommendation, Umbra will:

- Establish geographic exclusion zones ("GEZ") 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 when in range of RAS GEZs; and
- 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 Block Two 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 allows Umbra to share this spectrum with government systems without harmful interference. Umbra has demonstrated compliance with this coordination for its Block One satellites.

## 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 orbital debris mitigation requirements and has incorporated them, as appropriate, into its operational

---

[27] *See generally* Protection of the radio astronomy service in the frequency band 10.6-10.7 GHz from unwanted emissions of synthetic aperture radars operating in the Earth exploration-satellite service (active) around 9 600 MHz, Recommendation ITU-R RS.2066-0, RS SERIES - REMOTE SENSING SYSTEMS (Dec. 2014).

plans.[28] A more detailed description of the Orbital Debris Mitigation Plan is included in the ODAR, attached hereto as Exhibit B.[29] For convenience, a high-level summary of the ODAR is provided below.

### 8.1. Spacecraft Hardware Design

According to Umbra's analysis, no debris is released during normal satellite operations. Umbra is 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 PMD. However, Umbra satellites include on-board propulsion systems, which will be used to actively reduce the probability of collision with other known objects. Umbra has assessed the probability of collision using the most recent version of NASA's Debris Assessment Software (DAS v.3.2.3) and is compliant with every applicable NASA standard, as shown in its updated ODAR attached hereto as Exhibit B.[30]

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. The satellites will not expel any other matter besides the water used as fuel during thrust events, and any generated water ice crystals are expected to sublimate within minutes of exposure to sunlight. Therefore, there is no source of debris from operation of the propulsion system.

### 8.2. Minimizing Accidental Explosions

Umbra designs 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 PMD, further minimizing risk. The tanks are designed to contain <5 kg of

---

[28] *See* 47 C.F.R. § 25.114(d)(14); Exhibit B - Orbital Debris Assessment Report (ODAR).

[29] *Id.*

[30] *See id.*

water. The worst case on-orbit tank pressure for a full tank is 40 psi 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. Prior to deployment, Umbra will register all satellites with the 19th Space Defense Squadron ("19SDS") (or its successor entity). Following deployment, Umbra will identify and track its satellites using each satellite's unique telemetry marker and a network of ground stations. Because the satellites will be larger than 10 cm in their smallest dimension, they are presumed to be trackable. DAS analysis shows that the probability of collision with a large object is 0.00006, which is well below the 0.001 requirement.

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 will be continuously coordinating with the 19SDS (or its successor entity) through their existing conjunction reporting database to proactively address conjunction alerts. Upon receipt of a space situational awareness conjunction warning, Umbra will review and take all possible steps to assess and mitigate the collision risk as 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. Umbra will also be proactive in mitigating any risks from its deorbiting satellites to inhabitable orbiting objects, including, for example, the International Space Station ("ISS"). Umbra has a demonstrated track record of adherence to these procedures through its operations of five on-orbit spacecraft under the Block One License. Through these measures, Umbra will continue to be able to avoid collisions on an ongoing basis.

### 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, 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 U.S. over our TT&C channel. This approach has been discussed in pre-coordination with Federal operators for the previously authorized License and successfully tested on orbit.

## 9. POST-MISSION DISPOSAL

Each satellite in the Umbra Block Two Constellation is designed for a useful lifetime of five years and will be disposed of through atmospheric re-entry. Regardless of the satellites' launch date or operational lifetime, Umbra will actively deorbit all satellites within the applicable six-year license term[31] to ensure that the total in-orbit lifetime of each satellite is six years or less as required.[32] Additionally, the propulsion system is capable of deorbiting the satellites at any time during the license period. A more detailed discussion of the post-mission disposal plan is provided in Exhibit B.[33]

Umbra intends to lower its satellites post-mission into an elliptical orbit leaving apogee relatively unchanged and lowering perigee to 380 km. Simulations show that, in this configuration, the space craft will take two to three months to drop below the ISS orbit. Throughout this process, Umbra will continue to monitor spacecraft positions and pay careful attention to any Umbra spacecraft conducting PMD maneuvers. Umbra's space operations team will coordinate with other operators and work with organizations, such as the 19SDS, to send maneuver notifications and ephemeris updates one day in advance of all maneuvers, in addition to receiving regular conjunction notices. To the extent necessary,

---

[31] 47 C.F.R. § 25.121(a)(3) (licenses for applications filed pursuant to § 25.122 shall be issued for a period of six-years).

[32] 47 C.F.R. § 25.122(c)(2) ("The total in-orbit lifetime for any individual space station will be six years or less").

[33] *See* Exhibit B - ODAR, Section 7.3.

Umbra will perform collision avoidance maneuvers using differential atmospheric drag and any remaining fuel to reduce the probability of any conjunction warnings with sufficient advance notice.

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/ Gabrielle Jung

Gabrielle Jung

Spacecraft Systems Engineer
UMBRA LAB, INC.

Dated: April 11, 2023