UMBRA

September 21, 2021

Kerry E. Murray
Deputy Chief, Satellite Division
International Bureau
Federal Communications Commission
45 L Street, N.E.
Washington, D.C. 20554

Re: Umbra Lab, Inc., IBFS File No. SAT-LOA-20210616-00080; Call Sign S3095

Dear Ms. Murray:

In response to the International Bureau's letter dated September 2, 2021 (the Letter), Umbra Lab, Inc. (Umbra) provides the following additional information to assist in the review of Umbra's above-referenced application (the Application) requesting authority to construct, deploy, and operate six satellites (the Umbra SAR Constellation). For your convenience, the inquiries in the Letter are reproduced in italics below (without citations).

1. *The legal narrative states that the satellites will operate with altitudes at 500-600 km, with a "nominal" altitude of 583 km, in four orbital planes. However, the Schedule S lists the apogee and perigee of the satellites as 555 km and states they will operate in one orbital plane, and the technical attachment lists the perigee and apogee as 555 km ±55 km, and states both that the satellites will operate in six orbital planes and "up to six" orbital planes. Please clarify the configuration of the satellites in the Umbra SAR Constellation, including operational altitude, inclination, number of orbital planes, and tolerances for altitude and inclination maintenance.*

In light of our experience with Umbra-2001, we have determined that the ideal orbital altitude is 565 km (versus the previously stated 583 km). Therefore, the configuration of the satellites in the Umbra SAR Constellation should be as follows:

Operational Altitude: 565 km (nominal)
Inclination: 97.5° (nominal)
Number of Orbital Planes: 4
Tolerance for Altitude: 565 km ±30 km
Tolerance for Inclination Maintenance: 97.5° ±2°

The decrease to the nominal Operational Altitude does not materially affect any relevant calculations provided in the Application, including specifically the ODAR and power-flux density (PFD) calculations.

2. *In the legal narrative, Umbra states that only communications in the 2200-2290 MHz frequency band will be conducted using earth stations located outside the United States, but in the technical attachment, Umbra states that all communications will occur using earth stations located outside the United States. Please clarify what, if any, communications will be conducted with earth stations in the United States.*

The Umbra SAR Constellation will not communicate with any earth stations located in the United States.

3. *In the technical attachment, Umbra states that each satellite is designed for a useful lifetime of five years, at the end of which Umbra intends to dispose of the satellites through atmospheric re-entry. For a small satellite licensee, the maximum six-year license term for the system begins when the first satellite in the system is in orbit and has begun operating, so there appears to be a conflict between*

the five-year lifetime of the later-launched satellites and the six year license term for the system. For example, we note that Umbra plans to launch four satellites in 2022. These satellites must therefore have a shorter operational life than the satellites launched in 2021 in order to comply with the maximum six-year license term. Please clarify.

Umbra intends to deorbit all the satellites that are part of the Umbra SAR Constellation within the six-year license term specified by 47 CFR § 25.121(a)(3). Accordingly, satellites launched in 2022 will have a shorter operational life than satellites in the system launched in 2021.

4. *In the experimental application 0424-EX-CN-2020, the orbital lifetime of the satellite Umbra-2001 was stated to be eight years, not including post-mission disposal maneuvers. In the technical attachment of this application, the orbital lifetime of the Umbra satellites is listed as five years. Please confirm this change from what was authorized for the experimental-licensed satellite and provide a brief explanation.*

The referenced eight-year period stated in the experimental application represents the satellite's atmospheric reentry timeline in the worst case where a post-mission disposal (PMD) maneuver is not performed due to a failure.[1] The operational lifetime of Umbra-2001 is identified as five (5) years in the experimental application.[2] Accordingly, there has been no change.

For the avoidance of doubt, all Umbra satellites are designed for a useful operating lifetime of up to five (5) years. However, Umbra satellites will be deorbited in compliance with the six-year term required by 47 CFR § 25.121. A PMD maneuver will be performed to accelerate the deorbit process, as necessary to meet the six-year license term.

5. *The component lists appear different between the experimental application for Umbra-2001, 0424-EX-CN-2020, and this application. Please explain all differences and any updates that have been made. Please also clarify whether the six satellites in the Umbra SAR Constellation are technically identical.*

The ODAR submitted with the experimental filing applies to Umbra-2001, and the ODAR submitted with the Application applies to satellites Umbra 02 through 06. The component list provided in the experimental application was prepared from an earlier satellite design.

The updated component list and associated information reflects differences that fall into two categories, simulation adjustments and minor design refinements.

1. Simulation adjustments:

- Polycarbonate and aluminum components attached to the outer surface of top-level components that were included in the ODAR submitted with the experimental application were determined to demise at a very high altitude and were omitted in the ODAR submitted with the Application because the components had no material impact on ODAR analysis.
- Analysis for the primary bus structure was analyzed as individual panels in the ODAR submitted with the experimental application; this analysis was revised to model the bus structure as a large aluminum "box" in the ODAR submitted with the Application, per DAS examples.

[1] Umbra has shown that the probability of PMD failure complies with orbital debris requirements. Umbra Application, Attachment C – ODAR at 17.
[2] *See, e.g.*, Technical Exhibit, at 9, 16, ELS File No. 0424-EX-CN-2020 (February 9, 2021).

2. Design refinements to components:

- Final battery design allowed the batteries to be modeled independent of a dedicated chassis for each module.
- Design improvements to the electronics resulted in the removal of the DC/DC converters in favor of an Amplifier Assembly which is reflected in the new model.
- Added strut rods as a part of the payload structure.
- Electronics chassis designs were finalized and the largest and most stressing were included as three chassis weighing 0.14 kg each of which demises.
- The Solar Array mass was rounded up to 0.3 kg and included the mass of the cells and wiring as an extra measure of conservatism.
- SAR rib designs (primarily in the deployment mechanism) were revised to improve reliability and reduce complexity, allowing us to remove parts from the analysis that are no longer present.
- Base Ring mass was increased slightly due to a change in the material.

The six satellites are technically identical except for the minor differences in the component lists. Nonetheless, to the extent necessary to ensure compliance with 47 C.F.R. § 25.122(b)(2), Umbra certifies that Umbra-2001 also meets the requirements 47 C.F.R. § 25.122(c).[3]

Separately, in the ODAR Section 8.2[4] we indicated that three objects specified in Table 10[5] survive reentry, but inadvertently left off the last line with the third surviving object (Ti Hinge). The corrected table is provided below. To be clear, the addition of the Ti Hinge component to Table 10 does not represent a change. The component was already included in the orbital debris analysis provided in the Application.

Table 10. Spacecraft Component List for Human Casualty Risk Analysis

Name	Qty	Material	Body Type	Thermal Mass	Status	Risk	Demise Alt	Total DCA	KE
UMBRA 02	1	Aluminum (generic)	Box	60	Compliant	1:100000000		0	
Bus	1	Aluminum 7075-T6	Box	9			71.6	0	0
Battery	32	Aluminum (generic)	Cylinder	0.05			69.1	0	0
Torq Rods	3	Aluminum (generic)	Cylinder	0.3			68	0	0
Amplifier Assembly	1	Aluminum (generic)	Box	1.71			48.4	0	0
Strut Rod	6	Aluminum (generic)	Cylinder	0.094			66.5	0	0
Electronics Chassis	3	Aluminum 7075-T6	Box	0.14			66.7	0	0
MLB	1	Aluminum (generic)	Cylinder	0.7			75.3	0	0
Solar Array	6	Graphite Epoxy 1	Flat Plate	0.3			0	5.13	13.9
Reaction Wheels	4	A356	Cylinder	0.84			62.3	0	0
Prop Tanks	2	Aluminum (generic)	Cylinder	1			68.4	0	0
Largest Fastener	62	Stainless Steel (generic)	Cylinder	0.01			69.7	0	0
SAR rib	108	Graphite Epoxy 1	Flat Plate	0.07			0	84.55	0.99
Base Ring	1	Aluminum 7075-T6	Cylinder	0.14			77	0	0
Antenna Element	1	Aluminum 6061-T6	Flat Plate	0.28			77.3	0	0

[3] Umbra Application, Attachment A at 6 (certifying that all the Umbra satellites meet the requirements of 47 C.F.R. § 25.122(c)).
[4] Umbra Application, Attachment C – ODAR at 22.
[5] Umbra Application, Attachment C – ODAR at 21.

Canister	1	Aluminum 6061-T6	Cylinder	0.95			77.8	0	0
Ti Hinge	8	Titanium (6 Al-4 V)	Cylinder	0.003			0	3.02	0.47

6. *Please resubmit the antenna contour plots provided in the technical attachment in a larger and clearer format.*

Antenna contour plots are attached to this Letter.

7. *Please identify the assumed satellite altitude used for each power-flux density (PFD) value provided in the technical attachment was calculated.*

The assumed satellite altitude used for each PFD value calculation was 500 km.[6]

8. *In the orbital debris assessment report, Umbra states, "Umbra plans to create a process that flags an operator and executes propulsive maneuvers semi-autonomously, thereby minimizing the required time, propellant and tasking deltas required." Please provide more information regarding this process. Specifically, please describe the current stage of development for this process. Is it still in the design phase or has testing begun? If testing has begun, please provide detailed information on the tests performed and results to date. Please also detail what trigger(s) will cause the spacecraft to perform maneuvers, whether it is possible to override the autonomous process from the ground in the event of errors or emergencies, and whether the spacecraft continues to monitor the environment during a maneuver. Additionally, how many such maneuvers does Umbra expect a single spacecraft to perform during its lifetime? Will Umbra coordinate with nearby spacecraft operators prior to these autonomous maneuvers?*

Development of a semi-autonomous system for collision avoidance is currently in the early design phase. No tests of any semi-autonomous system have been conducted. Prior to conducting any such tests, Umbra will provide the Bureau with additional details regarding the system.

9. *In the technical attachment, Umbra provided detailed information regarding the applicability of Umbra's compliance with several footnotes to the International Table of Frequency Allocations. Please also provide this information for footnotes 5.476A, 5.478A, 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 and 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 the Earth are so short and utilize such a low duty cycle that the impact would be rare and inconsequential. Further, we have previously coordinated Umbra-2001 with federal operators, and they did not express any concerns about potential interreference. Accordingly, Umbra complies with footnotes 5.476A and 5.478B.

With respect to footnote 5.478A, Umbra's SAR transmissions require more than 500 MHz of bandwidth. Accordingly, use of the 9800-9900 MHz band is appropriate.

[6] Umbra Application, Attachment B at 10.

10. Please resubmit the ITU Cost Recovery letter using the template attached to this letter.

A revised ITU Cost Recovery Letter is attached to this Letter.

Unrelated to these responses, Umbra also takes this opportunity to update the LTAN specifications in the Application.[7] Below is a more accurate list of the expected LTANs for the Umbra SAR Constellation.

Satellite 1: 01:30
Satellite 2: 02:30
Satellite 3: 03:30
Satellite 4: 04:15
Satellite 5: 04:30
Satellite 6: 05:15

Sincerely,

/s/ Iulia Davies
Iulia Davies
Legal Counsel
Umbra Lab, Inc.

Attachments

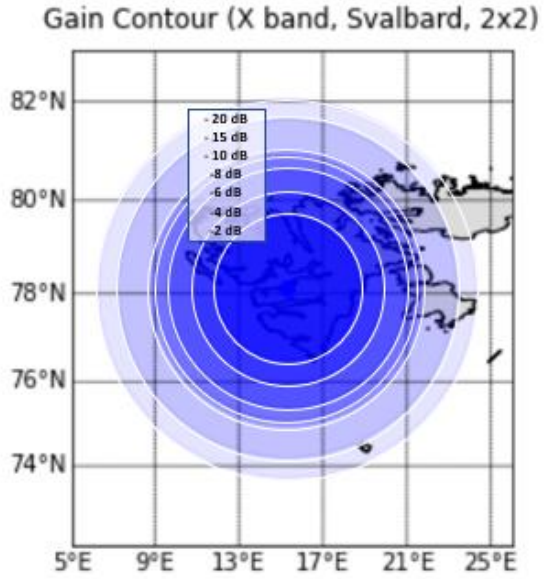
CC: Tony Lin
DLA PIPER LLP (US)
500 Eighth Street, NW
Washington, DC 20004
tony.lin@us.dlapiper.com

[7] Umbra Application, Attachment A at 4.

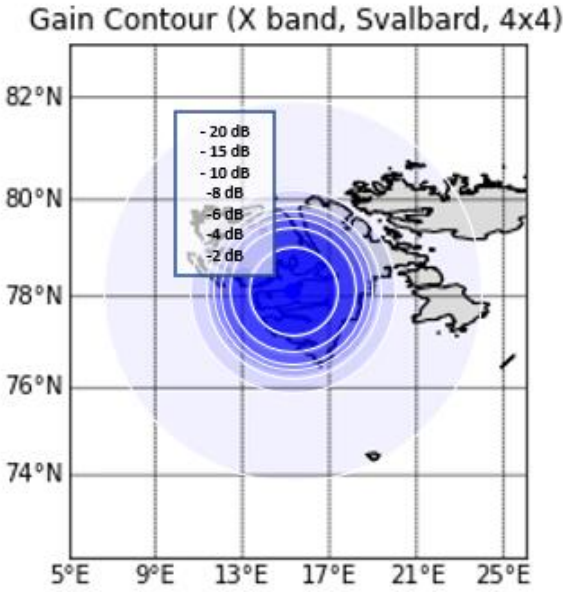
Umbra Lab, Inc.
IBFS File No. SAT-LOA-20210616-00080
Call Sign S3095

Attachment: Antenna Contour Plots

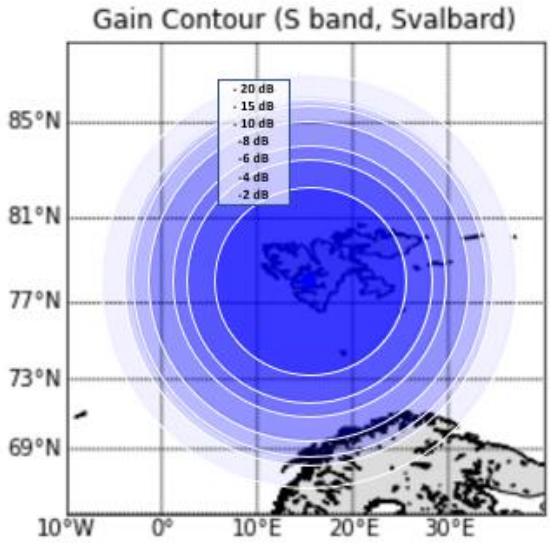
1. Gain Contour (X Band, Svalbard, 2x2)



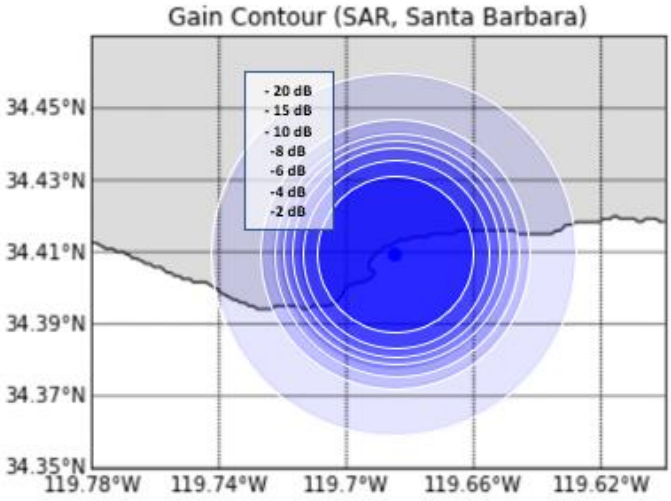
2. Gain Contour (X Band, Svalbard, 4x4)



3. Gain Contour (S Band, Svalbard)



4. Gain Contour (SAR, Santa Barbara)



UMBRA

September 21, 2021

Secretary
Office of the Secretary
Federal Communications Commission
45 L Street, N.E.
Washington, D.C. 20554

Subject: ITU Cost Recovery Declaration for the Umbra SAR Constellation Block 1 Satellite Network Operating in Non-geostationary Orbit in the Non-Planned Frequency Bands (Insert ITU satellite filing name).

Reference: FCC Application File No. SAT-LOA-20210616-00080; Callsign S3095

Dear FCC Secretary,

Umbra Lab, Inc. (Umbra) is aware that in accordance with Resolution 88 of the International Telecommunication Union's (ITU) Plenipotentiary Conference (Marrakech, 2002), and ITU Council Decision 482, as modified, cost-recovery fees will apply to satellite network filings received by the Radiocommunications Bureau after November 7, 1998. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU to process their satellite network filings. Umbra hereby states that it is aware of this requirement and unconditionally accepts all cost recovery responsibilities associated with the ITU filings for the Umbra SAR Constellation Block 1 satellite network. Please address all cost-recovery inquires, and ITU correspondence and filings, related to the Umbra SAR Constellation Block 1 satellite network to the following point of contact. We understand that should there be any change in the point of contact information, we will inform the Commission within 30 days of the foreseen event.

Point of Contact Name: Iulia Davies, Legal Counsel

Organization Name: Umbra Lab, Inc.

Address: 133 E De La Guerra Street, #39, Santa Barbara, CA 93101

E-Mail: iulia.davies@umbra.space

Telephone Number: (805) 455-3507

Umbra understands that it must remit payment of any resultant cost-recovery fee to the ITU by the due date specified in the ITU invoice, unless an appeal filed prior to the due date is pending with the ITU. We fully understand that a license granted in reliance on such a commitment will be conditioned upon discharge of any such cost-recovery obligation. We also acknowledge that, in accordance with 47 C.F.R. §25.111, should we have an overdue ITU cost-recovery fee and have no appeal pending with the ITU, the Commission may dismiss any application associated with that satellite network.

Sincerely,

/s/ Iulia Davies
Iulia Davies
Legal Counsel
Umbra Lab, Inc.