Capella Non-Geostationary Orbit Satellite Block 3 System
Attachment A

## Technical Information to Supplement Schedule S

### I. Scope and Purpose

This attachment contains the information required under Part 25 of the Commission's rules that cannot be fully captured by the associated Schedule S. The satellites described herein are virtually identical to Capella-3, Capella-4 and Capella-5 from a technical and operational perspective, which the Commission has previously authorized. Thus, the following technical information is substantively identical to that submitted in support of Capella-3, Capella—4 and Capella-5, except for the addition of a request for authorization of Capella's ground-based SAR calibration transmissions.

### II. Overall Description

Capella requests Commission authorization to deploy two non-geostationary orbit ("NGSO") satellites, in a single orbital plane. Capella satellites will use advanced synthetic aperture radar ("SAR") capabilities to offer extremely high-resolution monitoring while reducing costs and streamlining the satellite manufacturing process.

## A. Orbital Information

Capella seeks authorization for two satellites—Capella-7 and Capella-8—operating in a single orbital plane. The Capella satellites will include a propulsion system and, through regular corrective propulsive maneuvers by Capella, are anticipated to remain in their planned orbit within the ranges given below:

| | |
|---|---|
| Satellites per Plane | 2 |
| Inclination | 97.5 ± 3 º |
| Orbital Period | 5,708 ± 63 sec |
| Apogee | 525 ±50 km |
| Perigee | 525 ± 50 km |
| Argument of Perigee | N/A – Near Circular Orbit |
| Active Service Arc | Full Orbit |
| RAAN | 293 ± 15º |

*Table 1 —Orbital Parameters*

Complete orbital information is included in the associated Schedule S. Because of uncertainties regarding the precise timing of launch, it is impossible to provide a definite RAAN value. This constraint is common for operators such as Capella that use "ride-share" launch agreements and therefore do not have control over launch timing. However, like all NGSO satellites, the RAAN of Capella's satellites will precess across the full range of right ascensions from 0º through 360º. The value provided above is a possible value for this parameter given current launch schedules. Capella will provide a final RAAN value when it is available.

## III. Spectrum

Consistent with its current authorization, the Capella satellites proposed herein will operate in the following frequency bands:

| Link Name | Band | Center Frequency | Bandwidth |
|---|---|---|---|
| EES Sensing | 9300-9900 MHz | 9600 MHz | 600 MHz |
| Payload Downlink | 8025-8400 MHz | 8212.5 MHz | 337.5 MHz |
| TT&C Uplink | 2025-2110 MHz | 2036 MHz | 1.4 MHz |
| TT&C Downlink | 8025-8400 MHz | 8027 MHz | 1.4 MHz |
| Space-to-Space Uplink | 1525.0-1559.0 MHz | Assigned by Inmarsat | Assigned by Inmarsat |
| Space-to-Space Downlink | 1626.5-1660.0 MHz | Assigned by Inmarsat | Assigned by Inmarsat |

*Table 2 — Frequencies of Operation*

As shown above, Capella satellites will also communicate with Inmarsat satellites, pursuant to an agreement with Inmarsat, using a spaceborne Inmarsat BGAN terminal operating in the L-Band. The BGAN terminal will be capable of receiving in the 1525.0-1559.0 MHz band and transmitting in the 1626.5-1660 MHz band. These inter-satellite communications will be used for satellite tasking, allowing customer observation requests to be acted on immediately, without the need to wait until the appropriate satellite is within view of a Capella earth station, as would be required for other TT&C operations.

## IV. Technology and Operations

Capella satellites will use advanced SAR capabilities to offer extremely high-resolution monitoring of the Earth's surface with on-demand delivery of SAR imagery. Capella's systems are designed to avoid any harmful interference with other satellite systems—including other EESS systems—and protected terrestrial systems. They will meet all applicable power flux-density ("PFD") and other coexistence requirements even in a worst-case configuration. Moreover, due to the on-demand nature of Capella'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.

Capella has contracted with Amazon Web Services ("AWS") to use its AWS Ground Station service for all primary payload and TT&C communications with the SAR constellation. AWS Ground Station provides a "ground station as a service," with physical earth station infrastructure built and maintained by AWS in close proximity to AWS data centers. In addition to allowing more efficient allocation of the costs of constructing and operating the earth station facilities themselves, this offers an innovative and highly efficient means of acquiring, storing, and processing downlinked data. Capella has also contracted with Kongsberg Satellite Services for secondary earth station services in other locations.

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

Space stations in the SAR constellation will use several fixed antennas for payload and TT&C communications, as well as SAR sensing. The gain contours for each of these antennas is illustrated below and embedded in the associated Schedule S.

## A. X-Band Payload Downlink

The Capella X-Band payload downlink beam will have a maximum EIRP of 26.0 dBW in a 337.5 MHz channel, using both RHCP and LHCP polarizations, with the gain patterns shown in Figure V.A-1:

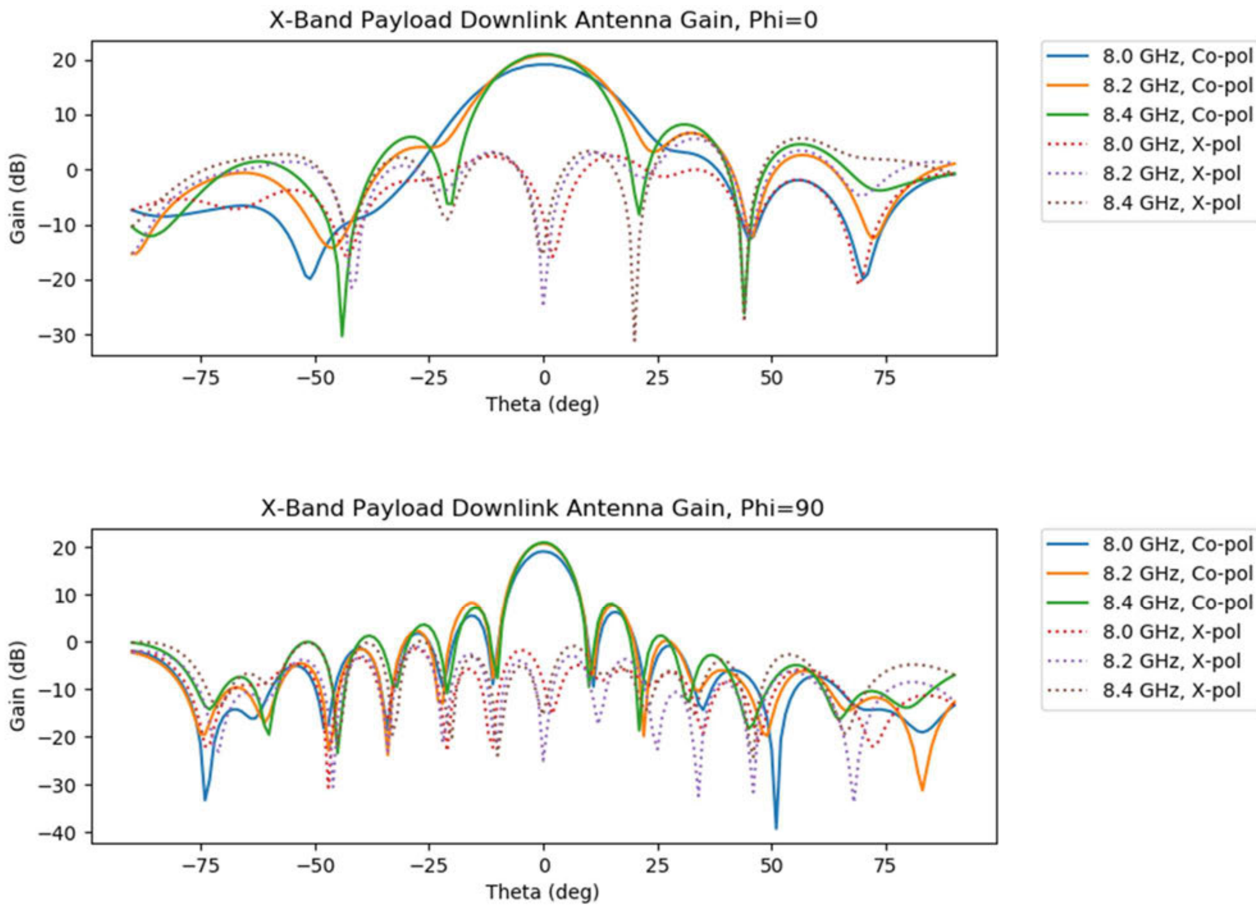


*Figure V.A-1. Capella X-Band Downlink Gain Patterns*

The gain contour showing the PFD projected onto the ground for a nominal X-Band payload downlink is set forth below in figure V.A-2:

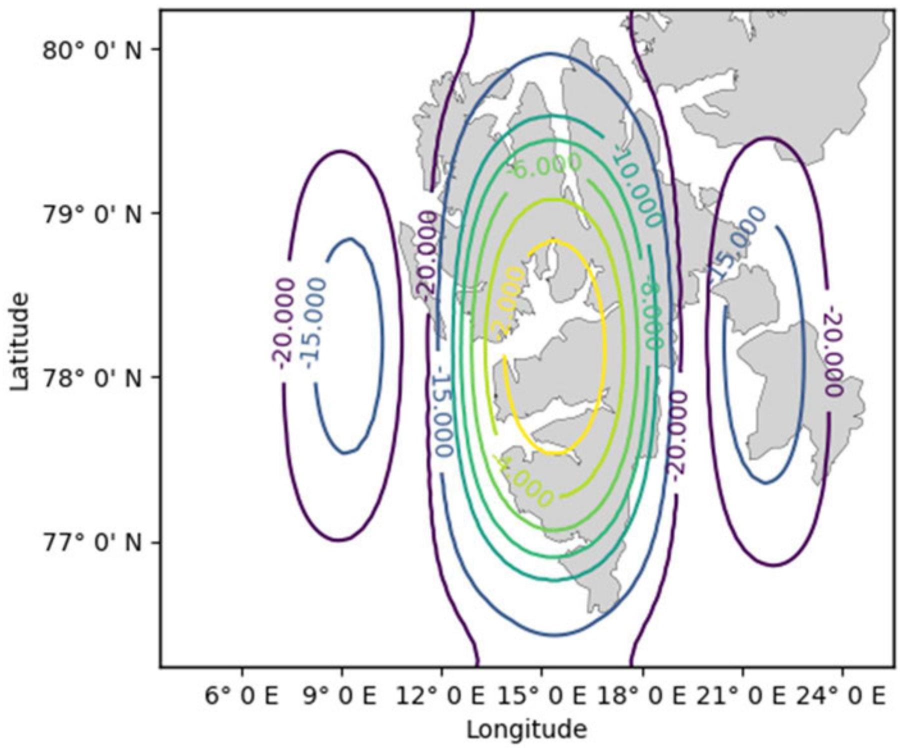


*Figure V.A-2. Capella X-Band Payload Downlink Ground-Projected Gain Contours for 575 km Altitude*

**B. X-Band TT&C Downlink**

The Capella X-Band TT&C downlink beam will have a maximum EIRP of 4.5 dBW in a 1.4 MHz channel, using RHCP polarization, with the gain patterns shown in Figure V.B-1 below:

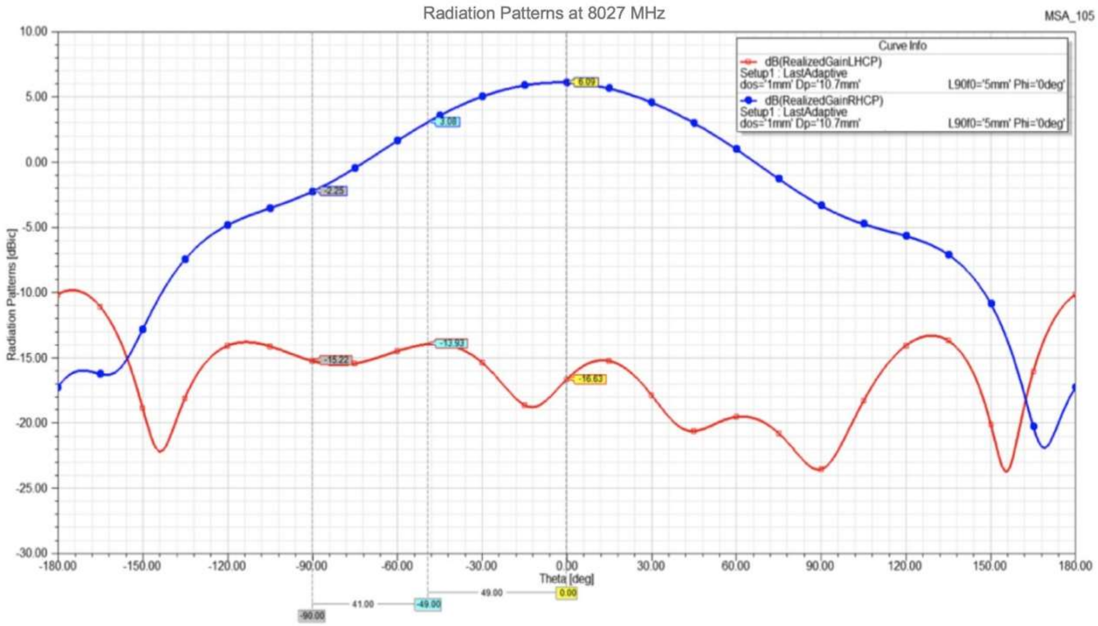


*Figure V.B-1. Capella X-Band TT&C Downlink Gain Pattern*

The gain contour showing the PFD projected onto the ground for a nominal X-Band TT&C downlink is set forth below in figure V.B-2:

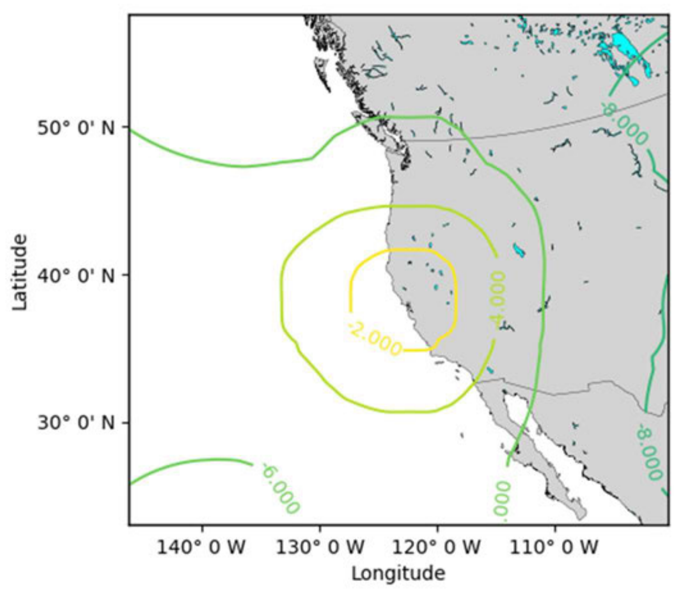


*Figure V.B-2. Capella X-Band TT&C Downlink Ground-Projected Gain Contours for 575 km Altitude*

## C. S-Band TT&C Uplink

The Capella S-Band TT&C uplink beam will have a maximum G/T of -23.4 dB/K, using RHCP polarization, with the gain pattern shown in Figure V.C-1 below:

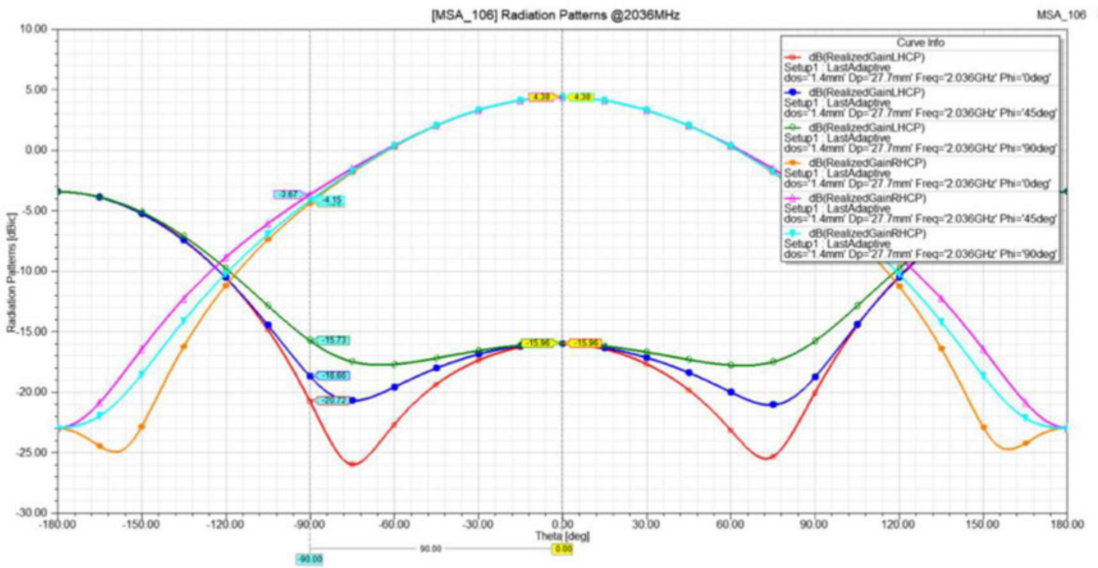


*Figure V.C-1. Capella S-Band TT&C Uplink Gain Pattern*

## D. X-Band SAR Antenna

The Capella X-Band SAR beam will have a maximum EIRP of 76.0 dBW in a 600 MHz channel, using linear polarization, with the gain pattern shown in Figure V.D-1 below:

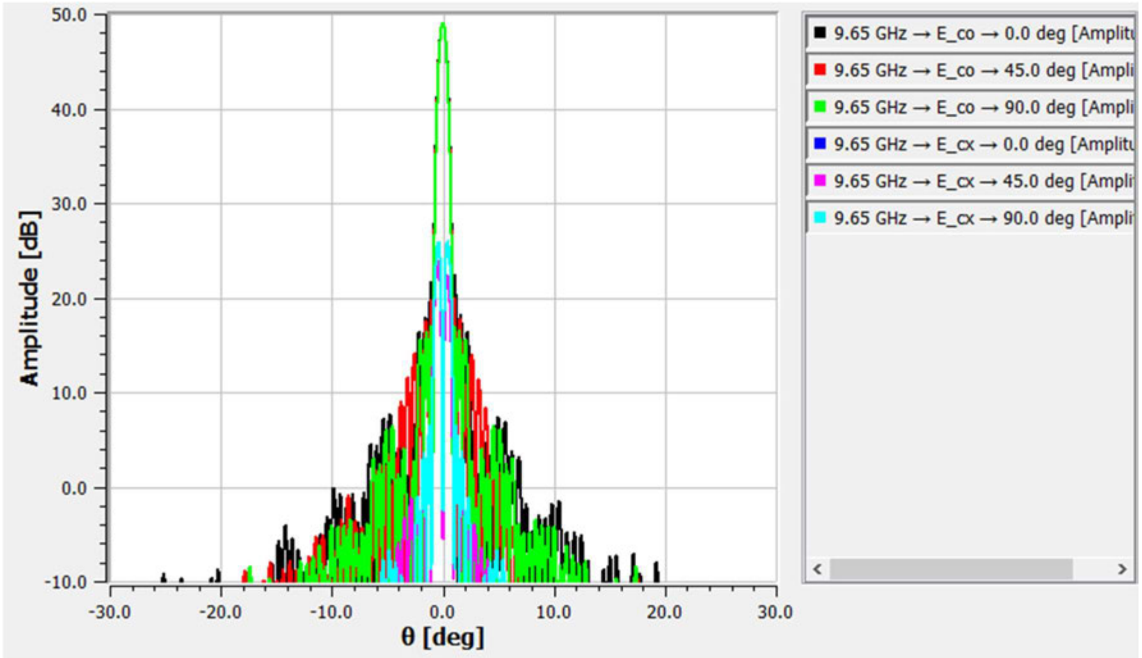


*Figure V.D-1. Capella X-Band SAR Gain Pattern*

The gain contour showing the PFD projected onto the ground for a nominal X-Band SAR for a 35 degree incidence angle is shown below in Figure V.D-2:

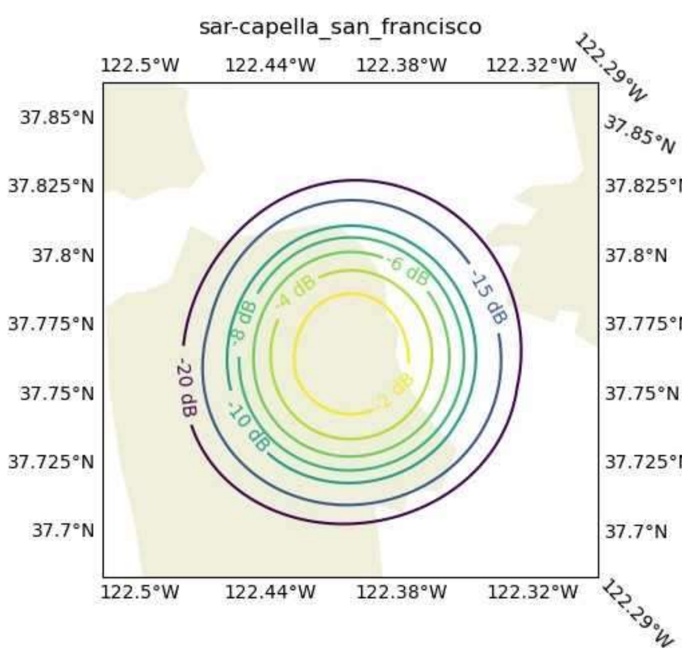


*Figure V.D-2. Capella X-Band SAR Gain Contour*

### E. Space-to-space uplink

Capella's space-to-space uplink[1] will have a maximum G/T of -18.6 dB/K with RHCP polarization, with the gain pattern shown in Figures V.E-1 and V.E-2 below. Inmarsat will assign an appropriate channel of operation and bandwidth, not to exceed 200 kHz.

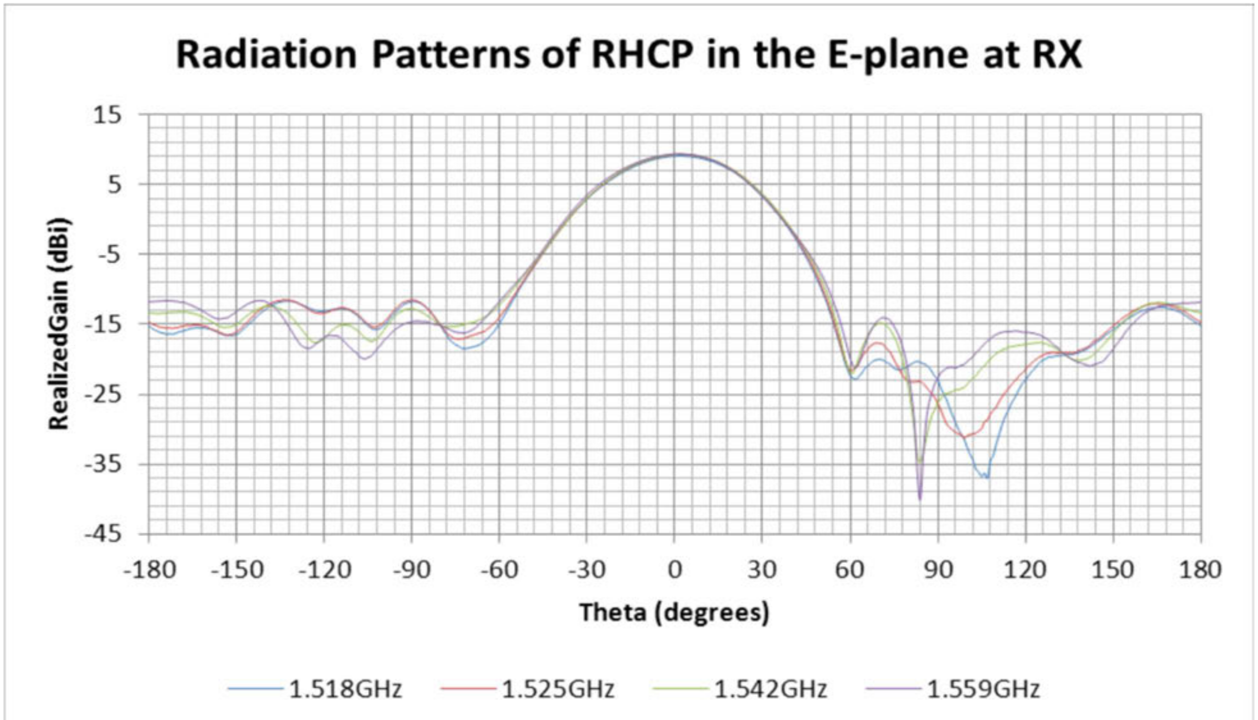


*Figure V.E-1. Capella Space-to-Space Uplink E-Plane Gain Pattern*

[1] In this case "uplink" refers to the link from the Inmarsat GEO satellite to the Capella LEO satellite.

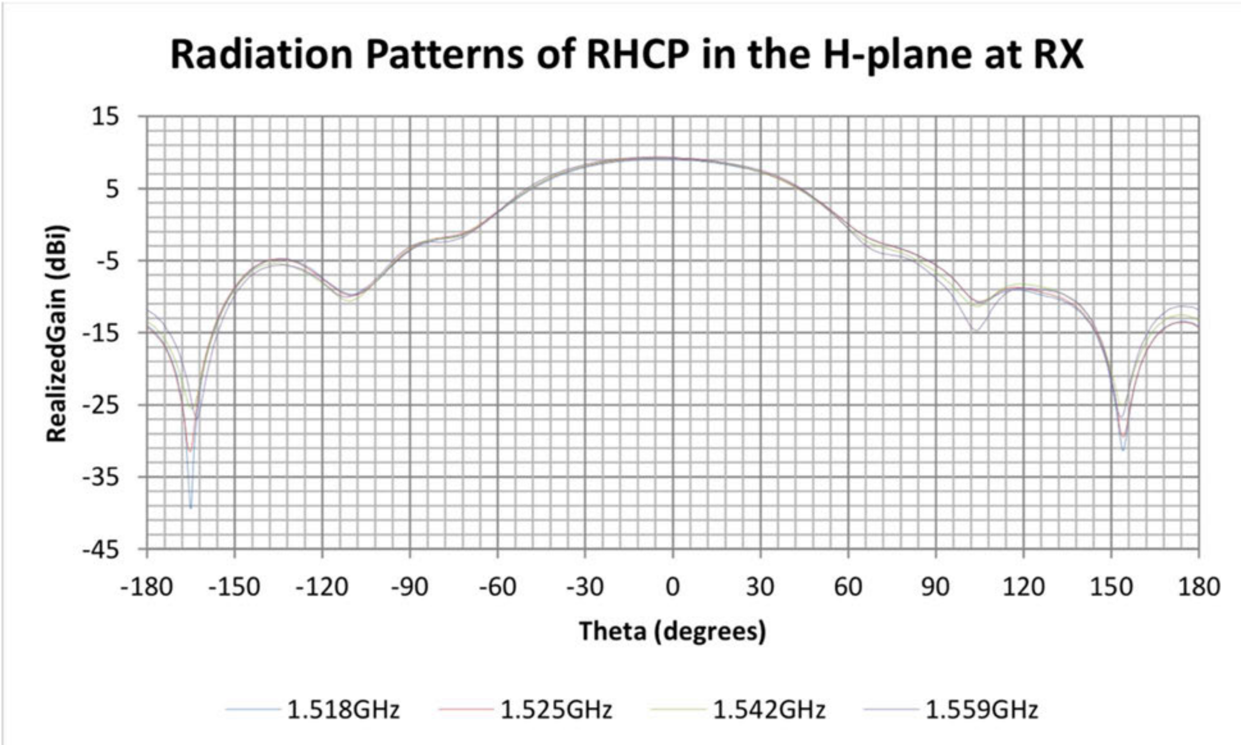


*Figure V.E-2. Capella Space-to-Space Uplink H-Plane Gain Pattern*

**F. Space-to-space downlink**

Capella's space-to-space downlink[2] will have a maximum EIRP of 8.5 dBW with RHCP polarization. Inmarsat will assign an appropriate channel of operation and bandwidth, not to exceed 200 kHz. Capella's space-to-space downlink will transmit with the gain pattern shown in Figures V.F-1 and V.F-2 below:

[2] In this case "downlink" refers to the link to the Inmarsat GEO satellite from the Capella LEO satellite.

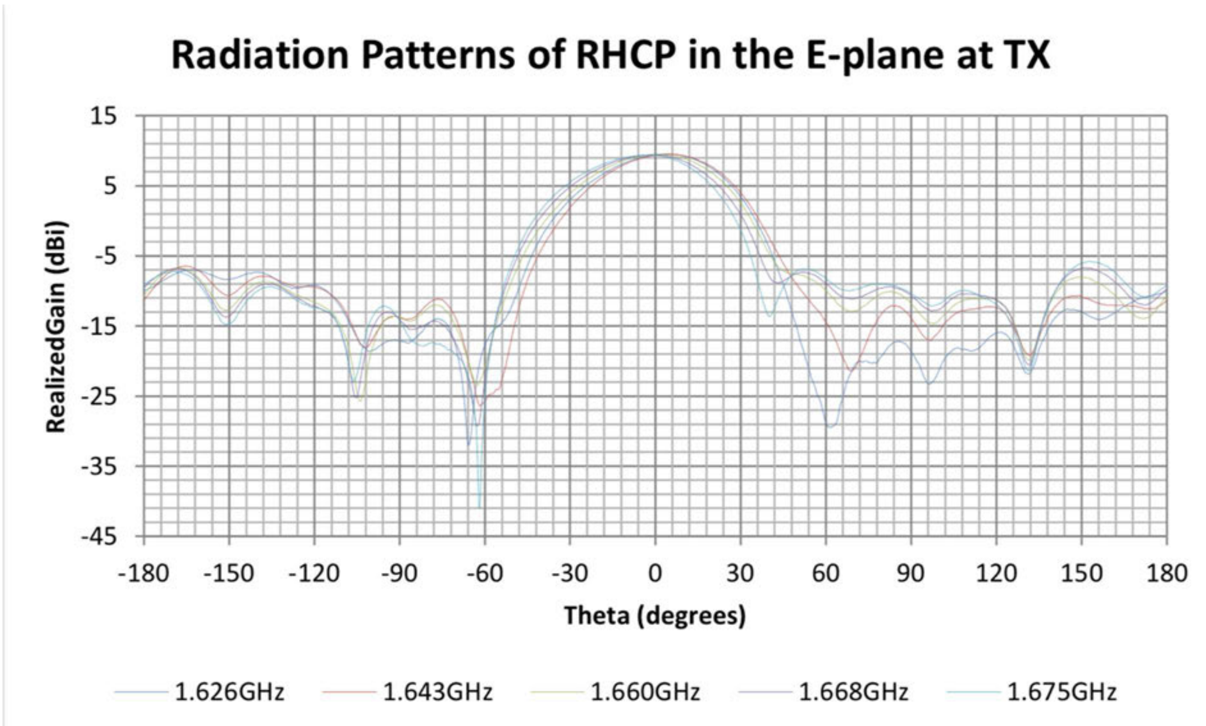


*Figure V.F-1. Capella Space-to-Space Downlink E-Plane Gain Pattern*

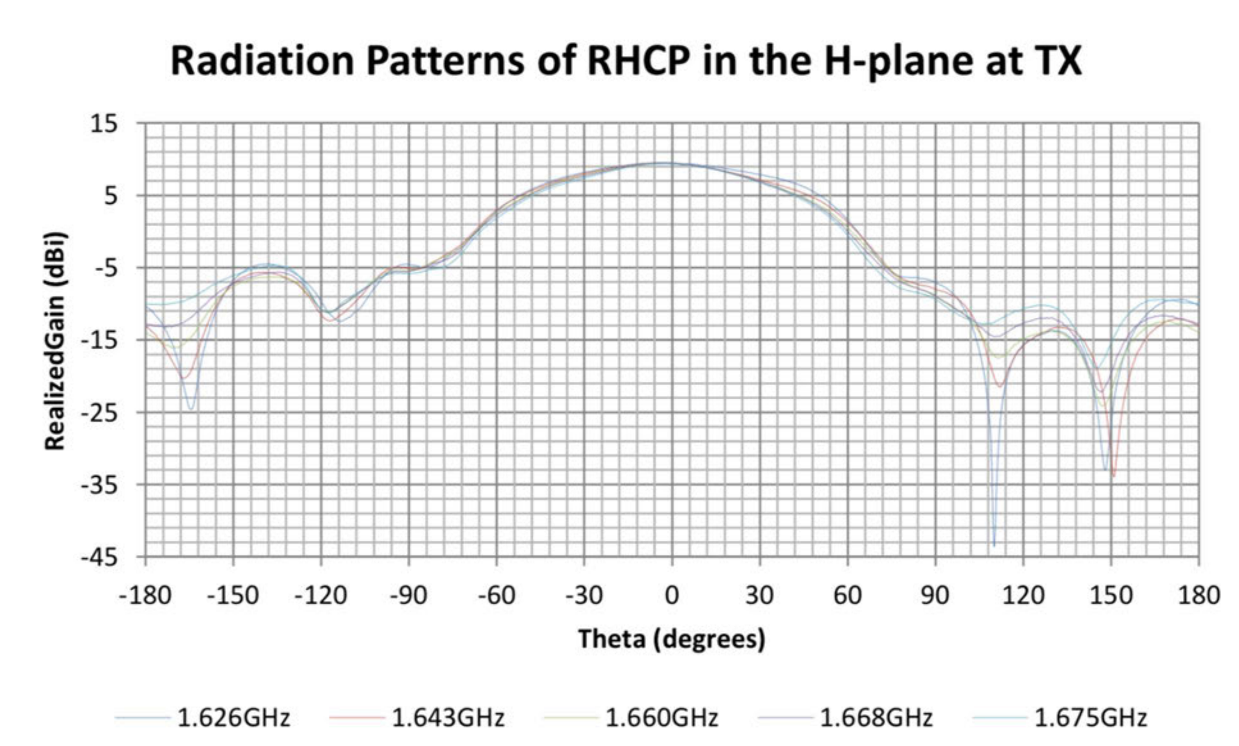


*Figure V.F-2. Capella Space-to-Space Downlink H-Plane Gain Pattern*

## VI. Cessation of Emissions

Each active satellite transmission chain (channel amplifiers and associated solid state 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.

## VII. Compliance with PFD Limits and Other Sharing Criteria

As detailed below, the SAR constellation will comply with all applicable Commission and ITU rules to ensure that it will share spectrum efficiently with other operators and that protected licensees will not experience harmful interference. Indeed, Capella has gone above and beyond these rules to ensure that its system will not impede the productive use of space by other operators.

### A. Power Flux Density Calculations in the 8025-8400 MHz Band

Section 25.208 does not include PFD limits at the Earth's surface for NGSO EESS emissions in the 8025-8400 MHz band. However, the ITU Radio Regulations provide the following limits, including emissions from a reflecting satellite, for all conditions and for all methods of modulation:

- −150 dB(W/$m^2$) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- −150 + 0.5(*d* -5) dB(W/$m^2$) in any 4 kHz band for angles of arrival *d* (in degrees) between 5 and 25 degrees above the horizontal plane;
- −140 dB(W/$m^2$) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.[3]

[3] ITU Radio Regs. Article 21, tbl.21-4 (2016).

In addition, Space Frequency Coordination Group ("SFCG") Recommendation 14-3R10 (use of the 8025-8400 MHz band by EESS) establishes that EESS satellites using directional antennas should be designed to limit the PFD on the Earth's surface in all areas with latitudes above 55 degrees or below −55 degrees to less than −145 dB(W/m$^2$) for a reference bandwidth of 4 kHz.[4] As shown in Figures VII.A-1 and VII.A-2 below, Capella will comply with all of these PFD limits.

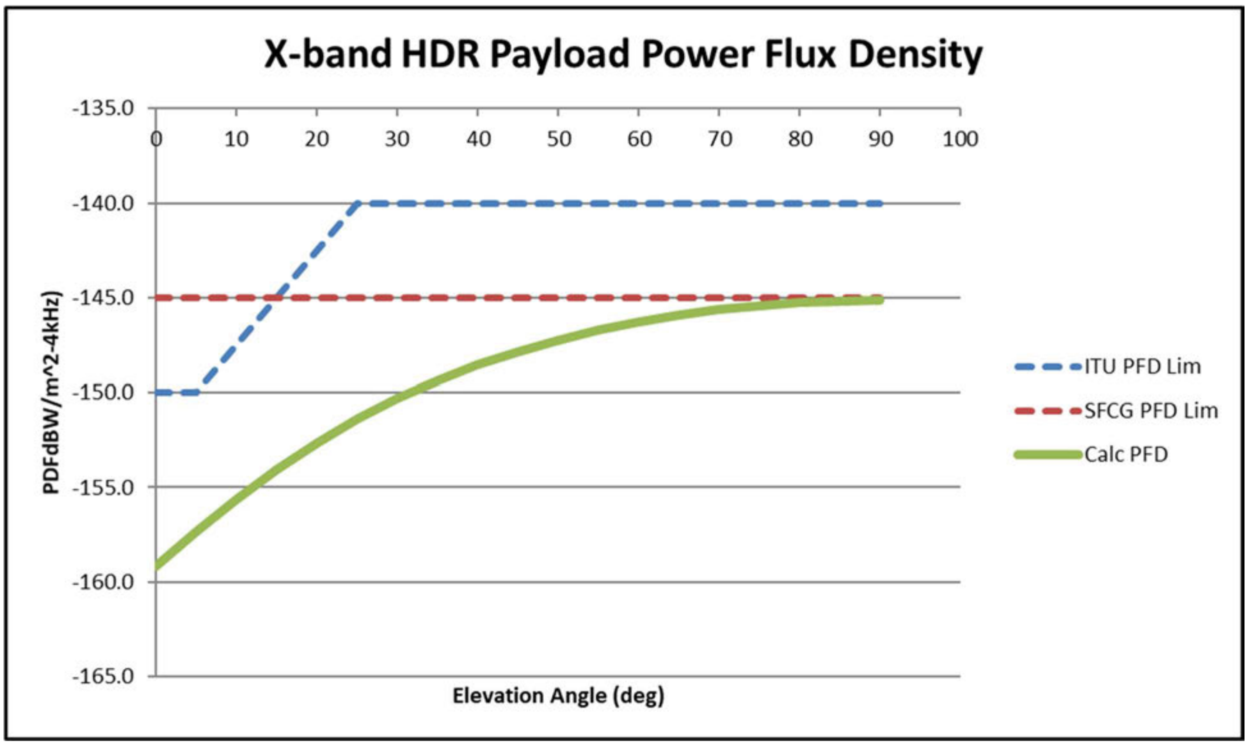


*Figure VII.A-1. Capella X-Band Payload Downlink PFD at Earth Surface*

[4] Space Frequency Coordination Group, *Use of the 8025-8400 MHz Band by Earth Exploration Satellites*, Recommendation SFCG 14-3R10, *Recommends* 6 (June 14, 2016).

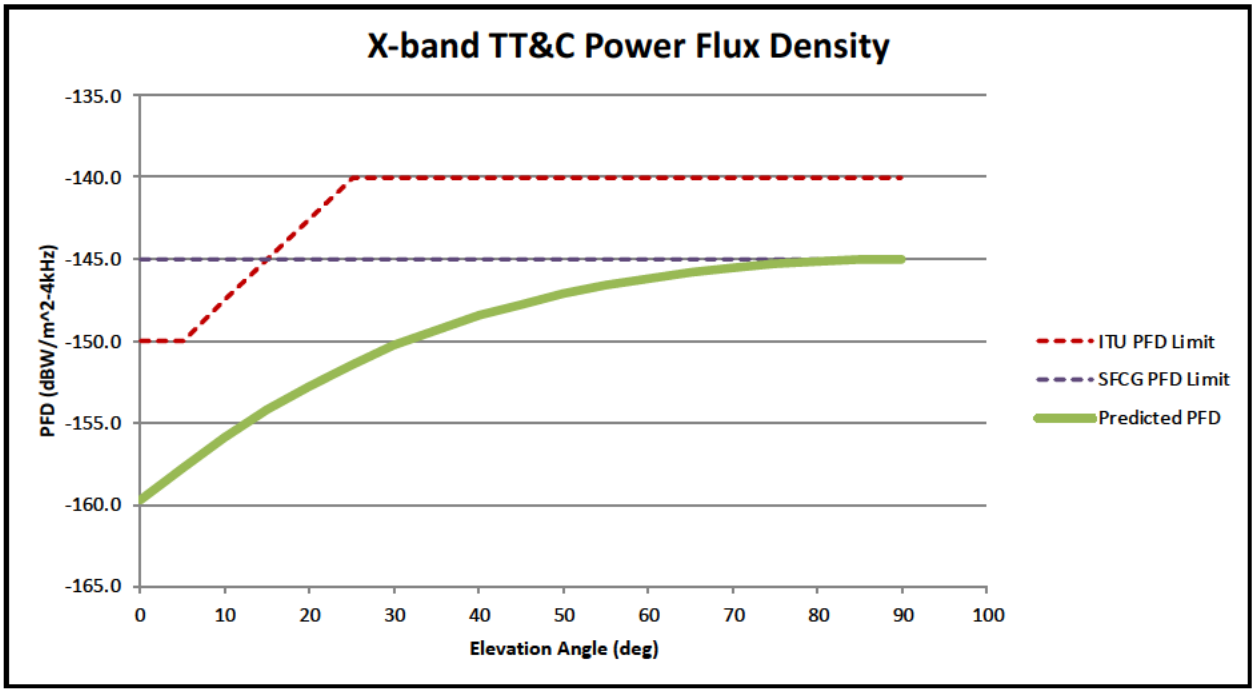


Figure VII.A-2. Capella X-Band TT&C Downlink PFD at Earth Surface

Commission rules do not require such compliance. However, Capella's compliance with both the ITU limits and the SFCG recommendation, designed to facilitate successful coordination of EESS frequencies, confirms that Capella's operations will promote efficient use of spectrum.

In addition, ITU Radio Regulation No. 22.5 specifies that the maximum PFD produced at the geostationary satellite orbit ("GSO") by any EESS space station in the 8025-8400 MHz band shall not exceed −174 dB(W/$m^2$) in any 4 kHz band, to ensure compatibility with operations in the fixed-satellite service (Earth-to-space) and the meteorological-satellite service (Earth-to-space). As demonstrated below, the PFD produced by the transmissions from the Capella satellites does not exceed the limit established in ITU Radio Regulation No. 22.5, even in the worst-case hypothetical scenario.

| Item | Value | Units | Notes |
|---|---|---|---|
| TX Freq | 8212.5 | MHz | |
| X-Band Downlink 3 dB Bandwidth | 150 | MHz | Worst-case BW for highest PFD |
| X-Band Downlink EIRP | 26.00 | dBW | |
| TX Output PSD | -55.76 | dBW/Hz | |
| TX Output PSD (4 kHz) | -19.74 | dBW | |
| Pointing Loss | 0 | dB | |
| Capella LEO Altitude | 575 | Km | Worst-case, highest orbit altitude |
| GEO Altitude | 35786 | Km | |
| Distance to GEO | 35211 | Km | |
| Path Loss | -201.66 | dB | |
| RX Pwr Flux Density (4 kHz) | -181.81 | dBW/m$^2$ | |
| Requirement | -174 | dBW/m$^2$ | Per ITU Radio Regulation No. 22.5 |
| **Margin** | 7.81 | **dB** | |

*Table VII.A-1. Capella X-Band Payload Downlink PFD at GEO*

| Item | Value | Units | Notes |
|---|---|---|---|
| TX Freq | 8027 | MHz | |
| X-Band TT&C Bandwidth | 1.4 | MHz | |
| X-Band TT&C EIRP | 4.50 | dBW | |
| TX Output PSD | -56.96 | dBW/Hz | |
| TX Output PSD (4 kHz) | -20.94 | dBW | |
| TX Pointing Loss | 0 | dB | |
| Capella LEO Altitude | 575 | km | worst-case, highest orbit altitude |
| GEO Altitude | 35786 | km | |
| Distance to GEO | 35211 | km | |
| Path Loss | -201.47 | dB | |
| RX Pwr Flux Density (4 kHz) | -183.01 | dBW/m$^2$ | |
| Requirement | -174 | dBW/m$^2$ | Per ITU Radio Regulation No. 22.5 |
| **Margin** | 9.01 | **dB** | |

*Table VII.A-2. Capella X-Band TT&C Downlink PFD at GEO*

Finally, ITU-R Recommendation SA.1157 specifies protection criteria for deep space earth station receivers in the 8400-8450 MHz band with power spectral density ("PSD") limited to −221 dBW/Hz at the inputs of deep space earth station receivers. As demonstrated below, Capella's proposed system satisfies this criterion with its currently contemplated ground stations and orbits. In the event that Capella seeks to serve a different configuration of earth stations that would otherwise cause PSD levels at a protected earth station to exceed −221 dBW/Hz, Capella will reduce power or signal bandwidth as necessary to ensure that its system continues to comply with these limits.

| Item | Value | Units | Notes |
|---|---|---|---|
| X-Band Downlink EIRP | 26 | dBW | |
| X-Band Downlink 3 dB Bandwidth | 250 | MHz | Worst-case BW for DSN Interference |
| X-Band Downlink PSD | -57.98 | dBW/Hz | |
| Spectral Roll-off @ 8.4 GHz | -32 | dBc | Measured with RRC alpha=0.35 |
| Output Filter Rejection @ 8.4 GHz | -50 | dB | Worst-case filter rejection |
| X-Band Downlink PSD @ 8.4 GHz | -139.98 | dBW/Hz | |
| Slant Range | 450.00 | Km | Worst-case + 25 km margin |
| Antenna Offset | 0.00 | Deg | Worst-case, DSN station at boresight |
| Pointing Loss | 0.00 | dB | |
| Space Loss @ 8400 MHz | -163.99 | dB | |
| Total Path Loss | -163.99 | dB | |
| DSN Earth Station Antenna Gain | 74.00 | dB | Per ITU-R SA.1157-1 |
| Received Interference PSD @ 8.4 GHz | -229.97 | dBW/Hz | |
| Protection Criterion | -221.00 | dBW/Hz | Per ITU-R SA.1157-1 |
| **Margin** | **8.97** | **dB** | |

*Table VII.A-3. Capella X-Band Payload Downlink Deep Space Earth Station Receiver Protection*

| Item | Value | Units | Notes |
| --- | --- | --- | --- |
| X-Band Downlink EIRP (dBW) | 4.5 | dBW | |
| X-Band Downlink Bandwidth (MHz) | 1.4 | MHz | |
| X-Band Downlink PSD (dBW/Hz) | -53.86 | dBW/Hz | |
| Spectral Roll-off @ 8.4 GHz (dBc) | -90 | dBc | Measured noise floor |
| X-Band Downlink PSD @ 8.4 GHz | -143.86 | dBW/Hz | |
| Slant Range | 450.00 | km | Worst-case + 25 km margin |
| Antenna Offset | 0.00 | deg | Worst-case DSN station at boresight |
| Pointing Loss | 0.00 | dB | |
| Space Loss @ 8400 MHz | -163.99 | dB | |
| Total Path Loss | -163.99 | dB | |
| DSN Earth Station Antenna Gain | 74.00 | dB | Per ITU-R SA.1157-1 |
| Received Interference PSD @ 8.4 GHz | -233.85 | dBW/Hz | |
| Protection Criterion | -221.00 | dBW/Hz | Per ITU-R SA.1157-1 |
| **Margin** | **14.95** | **dB** | |

*Table VII.A-4. Capella X-Band TT&C Downlink Deep Space Earth Station Receiver Protection*

## B. Compliance with ITU EESS System Design Guidelines

The ITU has issued ITU-R Recommendation SA.1810 relating to the design of EESS downlink transmission systems to maximize a system's ability to share spectrum with other EESS operators and deep space earth station receivers without causing harmful interference. Capella has complied with these guidelines in the design of its system.

## C. Sharing Considerations in the 9300-9900 MHz Band

The 9300-9900 MHz band is allocated for EESS (active) operations such as Capella's planned SAR sensing on a co-primary basis with terrestrial radiolocation services. As demonstrated below, the Capella system will not cause harmful interference to these operations.

### 1. *Protection of Terrestrial Radionavigation and Radiolocation Services*

ITU-R RS.1280 provides guidance on maximizing compatibility between spaceborne and terrestrial radar systems. That recommendation notes that the last 20 years has shown no record of harmful interference caused by spaceborne SAR operations. In this time, a number of spaceborne SAR systems have been operating, including the German TerraSAR-X and TanDEM-X systems, and the Spanish PAZ system, all of which have an EIRP value of 79 dBW—double the radiated power of the Capella radar (EIRP of 76 dBW). As a result, there is no reason to anticipate that the Capella system will cause harmful interference when these other systems have not.

In addition, RS.1280 provides a methodology for assessing whether the peak or average power of an active spaceborne sensor exceeds that of the example terrestrial sensors provided in the recommendation. That methodology demonstrates that Capella SAR transmissions are lower than the example radars provided in the recommendation. Moreover, the Capella system will only transmit for brief periods, and over a limited geography at a given moment in time. Thus, and in view of the analysis, transmissions from the Capella SAR system will have no material effect on terrestrial radar systems.

Capella's spaceborne SAR sensing will present a much smaller PFD compared to authorized terrestrial radionavigation devices in the band. For example, the EIRP of marine navigation radars operating in the band is around 64 dBW (25 kW transmit power, 20 dB isotropic antenna gain), and these transmitters are often very close to other radionavigation and radiolocation services. Although the Capella radar EIRP is larger (76 dBW), the propagation (spreading) loss for the Capella radar will be more than 114 dB (500 km). For a marine navigation radar that is 1 km from the terrestrial radar transmitter, the propagation loss is only 60 dB. As a result, the PFD of the Capella radar transmitter at a terrestrial receiver will be far lower: terrestrial radars would be received at 4 dBW (64 dBW – 60 dB = 4 dBW) while the Capella SAR transmissions would be received at less than -38 dBW (76 dBW – 114 dB = -38 dBW).

*2. Protection of Terrestrial Radar Beacons*

Footnote 5.427 of the Commission's Table of Frequency Allocations requires 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.[5] Capella's satellites will not be equipped with radar transponders, eliminating the interference risk contemplated by this footnote.

Moreover, Capella's SAR transmissions in this band will not themselves be confused with radar beacons due to the fundamentally different timing, duration, and other characteristics of radar beacon signals compared to Capella's SAR transmissions. In addition, as demonstrated above with respect to footnote 5.476A, Capella's transmissions will not cause harmful interference to ship or aeronautical radars in the radionavigation service.

**D. Sharing considerations in the 1525-1559 MHz and 1626.5-1660 MHz bands**

Capella seeks authorization to engage in space-to-space operations in the 1525-1559 MHz and 1626.5-1660 MHz bands on a nonconforming basis. These transmissions will occur only on frequencies that Inmarsat assigns to the spaceborne Inmarsat BGAN terminal onboard the Capella satellite. As with its other operations, Inmarsat will assign channels to Capella satellites consistent with its coordination agreements with other operators in the band, ensuring that there is no harmful interference between these systems. Furthermore, in the 1525-1559 MHz band, Capella's operations will be receive-only. The received signals will be transmitted by Inmarsat satellites with the same technical parameters as Inmarsat would use to communicate with its authorized MSS terminals on the Earth's surface.

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[5] *See id.* n.5.427.

## VIII. Coordination with U.S. Government Systems

There are a variety of federal allocations in the bands used by the SAR constellation. Capella has provided various U.S. government agencies initial information on the operational parameters of its system, and is committed to successful coordination with all government satellite and terrestrial networks operating in these bands to protect critical national security and government systems. Capella has signed a coordination agreement with the National Aeronautics and Space Administration ("NASA"), the U.S. Air Force and other federal agencies regarding Capella operations in the 8025-8400 MHz band. For the reasons discussed above, Capella is confident that the characteristics of its proposed system will facilitate an operational approach that will allow Capella to share this spectrum with government systems without harmful interference.

## IX. ITU Filings

No information has yet been submitted to the ITU for the additional two satellites described in this application. Capella understands that additional ITU filings will be required and will unconditionally accept all consequent ITU cost recovery responsibilities.

## X. Orbital Debris Mitigation

Capella has incorporated the material objectives set forth in this application into the technical specifications established for design and operation of its NGSO system. Capella has internally reviewed orbit debris mitigation requirements and has incorporated them, as appropriate, into its operational plans.

## A. Spacecraft Hardware Design

Capella has assessed and limited the amount of debris released in a planned manner during normal operations and does not intend to release debris during the planned course of operations of its system. Capella 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. Capella has assessed the probability of collision using NASA's Debris Assessment Software (DAS v.3.1.2) and is compliant with every NASA standard. The probability of damage from a small object at the nominal altitude of 525 km is 0.00026, much below the compliance thresholds established by ODAR requirements.

Capella satellites also include on-board propulsion systems which will be used to actively reduce the probability of collision with other known objects. Capella is working with CSpOC on monitoring collision probability for its systems and has already successfully demonstrated collision avoidance maneuvers with its experimental satellite Capella-1. Capella has completed an ODAR Report for the three satellites described in this application which is attached as an appendix to this application.

Capella is undertaking steps to address this possibility by incorporating redundancy, shielding, separation of components, and other physical characteristics into the satellites' design. The propulsion system for Capella-7 and Capella-8 will contain 1,000g of xenon propellant. Capella spacecraft will not expel any other matter besides the xenon used as fuel during thrust events, eliminating any source of debris. Capella will continue to review these aspects of on-orbit operations throughout the spacecraft design and manufacturing process and will make such adjustments and improvements as appropriate to ensure that its spacecraft will not become a source of debris during operations or become derelict in space due to a collision.

## B. Minimizing Accidental Explosions

Capella is designing its spacecraft in a manner that limits the probability of accidental explosion. Capella 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, Capella has taken steps to ensure that debris generation will not result from the conversion of energy sources onboard the Capella 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. But even 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 1,300g of xenon. The worst case on-orbit tank pressure for a full tank is 3,000 psia at 75°C. The tank temperature is not expected to exceed 45°C on orbit. The tanks have been designed and tested for a burst pressure of 6,000 psia. There is a 100% margin on the tank's burst pressure, ensuring that there is no risk of accidental explosion of the propulsion system.

## C. Safe Flight Profiles

Through detailed and conscientious mission planning, Capella 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 0.00003—again, compliant with NASA and Commission standards. Capella is willing to engage with any operators of nearby constellations and other space stations to ensure safe and coordinated space operations.

Capella will be proactive in ensuring that any risks to inhabitable orbiting objects posed by a Capella satellite are mitigated. This will include coordinating with NASA to ensure protection of the International Space Station on an ongoing basis, and coordinating with the China National

Space Agency with respect to Tiangong-2 and successor vehicles. Capella will provide all relevant agencies with any information they need to assess risks and ensure safe flight profiles, as well as contact information for Capella personnel on a 24 hours per-day/7 days per-week basis. Through these measures, Capella will be able to avoid collisions on an ongoing basis. No proximity operations are planned.

Capella confirms that it intends to perform collision avoidance procedures, including conjunction assessment, execution of avoidance maneuvers, and trajectory planning for any significant planned alterations of satellite trajectory, and notification to other potentially affected operators of any planned alteration of a satellite's trajectory for all phases of operations. Capella 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.

Capella has assessed its proposed orbit to identify any characteristics that might present a collision risk, including an assessment of other space stations in or near those orbits. The proposed Capella orbit could overlap with the SpaceX Starlink orbital plane at 53 degrees inclination and a nominal altitude of 550 km. However, the nominal orbits of these systems will be separated by 25 km. In addition, both SpaceX and Capella will have propulsive capabilities that can be used for collision avoidance. As with all other operators, Capella will perform conjunction assessments for SpaceX Starlink satellites and will actively coordinate with SpaceX to prevent collisions.

Capella recognizes that the Commission has authorized Spire Global to deploy satellites at a variety of altitudes from 400 km to 650 km, has authorized Kepler Communications to deploy satellites in near-polar orbits at a range of altitudes from 500 km to 600 km, and has authorized Kuiper Systems LLC to deploy satellites at an altitude of 581-599 km. Capella will engage with these operators and any other system seeking to operate at the same nominal altitudes proposed for Capella's operations in this application to carefully coordinate physical operations to ensure that their respective constellations can coexist safely.

Prior to deployment, Capella will register its satellites with the 18th Space Control Squadron (or a successor entity). Following deployment, Capella will actively identify and track its satellites using a network of ground stations that will establish contact with the satellites. Capella 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 Capella satellites will be larger than 10 cm in their smallest dimension, they are presumed to be trackable. Nonetheless, Capella 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. Capella 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.

## XI. Post-Mission Disposal

Each satellite in the SAR constellation is designed for a useful lifetime of three to four years, at the end of which Capella intends to dispose of satellites through atmospheric re-entry. At the end of the mission operations, the attitude control system can orient the satellite into a maximum drag configuration with the solar panels and SAR antenna in the direction of the velocity, accelerating orbital decay. This configuration is the stable equilibrium under gravity gradient and drag, which means that even in the case of Attitude, Determination, and Control System ("ADCS") failure, the satellite will eventually assume this position naturally. In the case where some leftover propellant is available at the end of the nominal mission lifetime, propulsion can be used to further decrease the duration of atmospheric reentry and avoid potential collisions. Assuming an apogee of 575 km (worst-case) and nominal end-of-life configuration, atmospheric re-entry occurs less than 18 months after end of mission lifetime. Even in the worst-case scenario where the minimum drag configuration is maintained throughout the entire disposal period, the Capella satellite will reenter within four years, which is well within the acceptable 25-year re-entry time.

Capella has conducted a preliminary re-entry risk analysis using DAS. The spacecraft was modeled to a level of fidelity that included 13 major components. As modeled, DAS indicates the entire satellite will burn up during uncontrolled re-entry with no material surviving to reach the Earth's surface. Accordingly, the risk of human casualty on the ground from Capella satellites re-entering the atmosphere is 1:100000000.[6]

[6] DAS is not capable of producing a value of exactly zero under any circumstances, with the minimum value of 1:100000000 serving as its functional equivalent.

## XII. Temporary authorization for ground-based calibration signal

In addition to the commercial operations described above, Capella requests authority to operate a ground-based system for calibrating Capella's synthetic aperture radar systems for a limited period following deployment of the radars in space. These operations will be limited to brief periods of transmission of a low power signal from the ground to the spacecraft. The ground-based system will transmit a calibrated CW tone in the direction of the spacecraft as it passes overhead. The tone will be tuned to the frequency of the Capella radar and the power level carefully controlled. The ground-station antenna will track the spacecraft using a commercial off-the-shelf computer-controlled telescope mount. The power received by the spacecraft radar receiver will be used to calibrate radar measurements. The ground station will follow the spacecraft as the spacecraft traverses the sky but transmit only when the spacecraft is more than 10 degrees above the horizon. Orientation of the ground station antenna in the horizontal plane (degrees from true north) and orientation in the vertical plane (degrees from horizontal) will vary continuously as the ground station transmits.

The characteristics of these transmissions are specified below. (Because these transmissions will originate exclusively from the ground, they cannot be captured on the associated Schedule S.)

**Transmitter Location**:
San Francisco, CA
Within 50 miles of 37° 46' 26" N, 122° 25' 52" W
Height: < 6m

**RF Characteristics**:
Frequency: 9.4 – 9.9 GHz +/- 0.00025%
Output Power: 25W / 1412.5 W EIRP (Peak)
Beamwidth at the half-power point: 12°

**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.

/s/ *Duncan Eddy*

Duncan Eddy
Director, Space Operations
CAPELLA SPACE CORP.

July __, 2021

Date