Capella Non-Geostationary Orbit Satellite 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.

II. Overall Description

Capella requests Commission authorization to deploy two of Capella's "Acadia" class non-geostationary orbit ("NGSO") satellites. These Capella satellites will expand Capella's ability to provide current, high-resolution synthetic aperture radar ("SAR") data to commercial as well as U.S. and foreign allied government customers.

A. Orbital Information

Capella seeks authorization for two satellites, Acadia-1 and Acadia-2 (the "Capella Satellites"). Both satellites will include propulsion capabilities and, through regular corrective propulsive maneuvers, are anticipated to remain in their planned orbit within the ranges given below for the duration of their mission:

Satellites per Plane	2
Inclination	42-56 º
Orbital Period	5,801 ± 31 sec
Apogee	600 ±25 km
Perigee	600 ± 25 km
Argument of Perigee	N/A – Near Circular Orbit
Active Service Arc	Full Orbit
RAAN	293 ± 15º

Table 1 —Orbital Parameters

These satellites are expected to be initially deployed at altitudes of 585-615 km and will achieve their intended operational altitudes through one or more orbit-raising maneuvers, if necessary. In addition, while Capella plans to operate the satellites within the altitudes described above during their planned three-year operating lifetime, Capella may continue to leverage the SAR sensing capabilities of these satellites throughout the deorbit process at the end of the satellites' useful life, at an altitude no lower than 400 km.

Complete orbital information is included in the associated Schedule S. Because of uncertainties regarding the precise timing of launch, there may be limited changes to these anticipated orbital parameters. In particular, because of uncertainties regarding the precise timing of launch, it is impossible to provide a definite RAAN value. Like all NGSO satellites, the RAAN of the Capella 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 promptly notify the Commission in the event that Capella's launch arrangements necessitate any changes to the orbital information provided above.

III. **Spectrum**

The Capella Satellites will operate in the following frequency bands:

Link Name	Band	Center Frequency	Bandwidth
EES Sensing	9300-10000 MHz	9650 MHz	700 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, the 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 terminals will be capable of receiving in the 1525.0-1559.0 MHz band and transmitting in the 1626.5-1660 MHz band. These 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. In fact, the larger

bandwidth of the Acadia-class SAR beam will allow Capella to collect data with even greater fidelity than with the previous generation of Capella satellites, meeting the evolving needs of Acadia's U.S. government, allied government, and commercial users. As demonstrated below, 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, payload and sensing transmissions will occur infrequently and with low PFD on the ground, further minimizing the risk of interference.

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 and Atlas Space Operations for secondary earth station services in other locations.

V. Predicted Space Station Antenna Gain Patterns and Contours

The Capella Satellites 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:

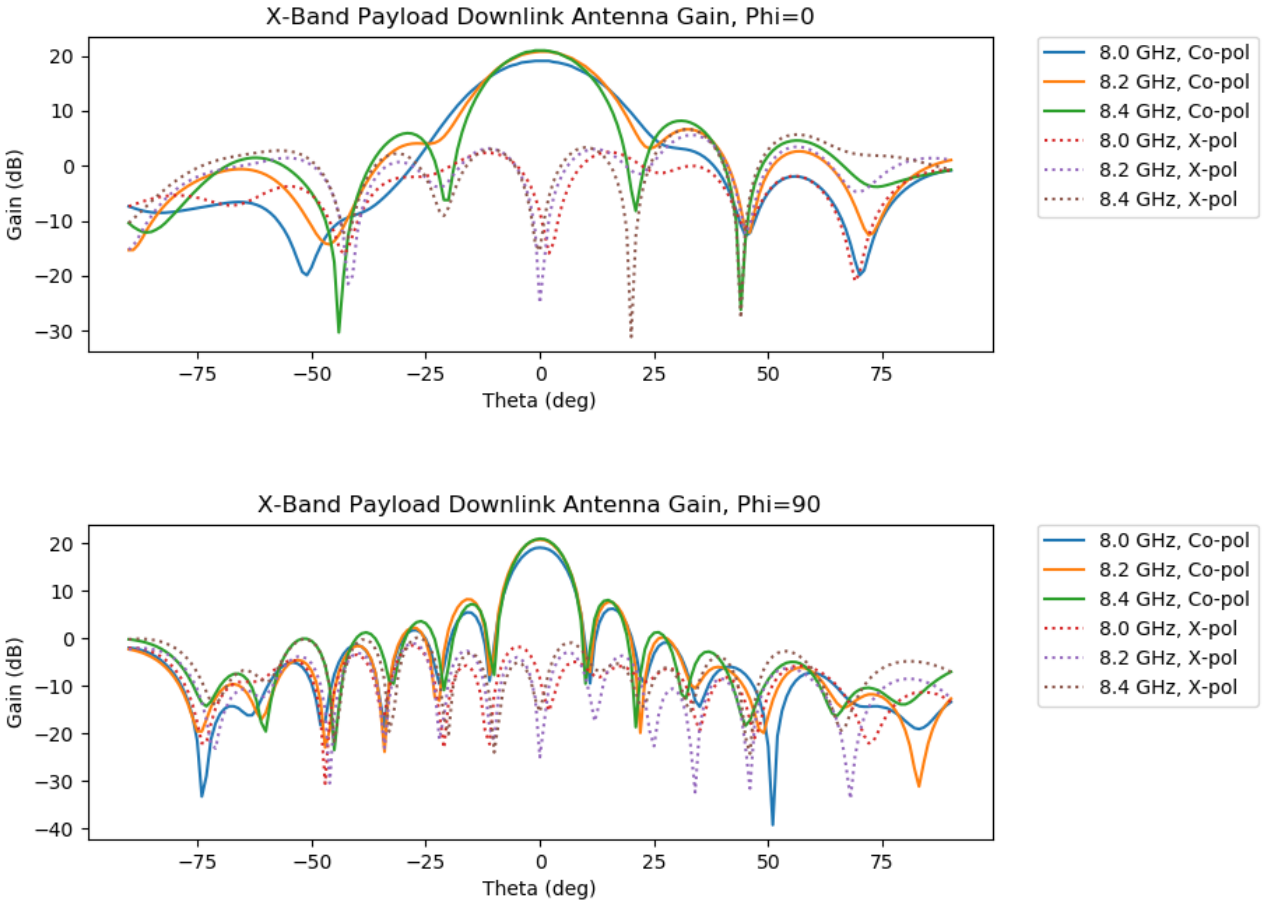

Figure V.A-1. Capella X-Band Downlink Gain Patterns

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:

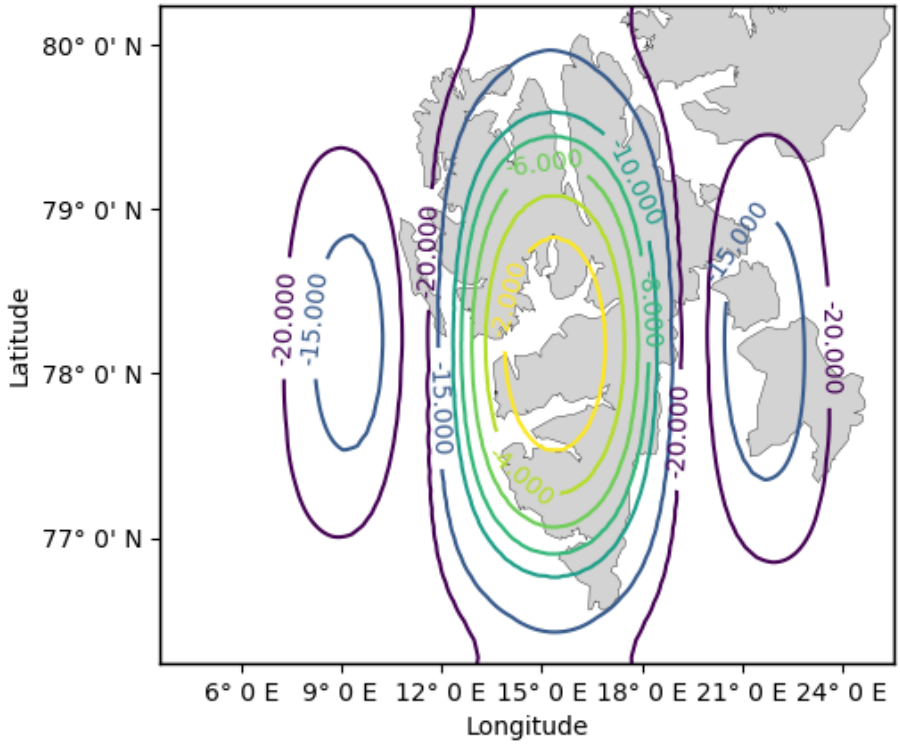

Figure V.A-2. Capella X-Band Payload Downlink Ground-Projected Gain Contours for 575 km Altitude

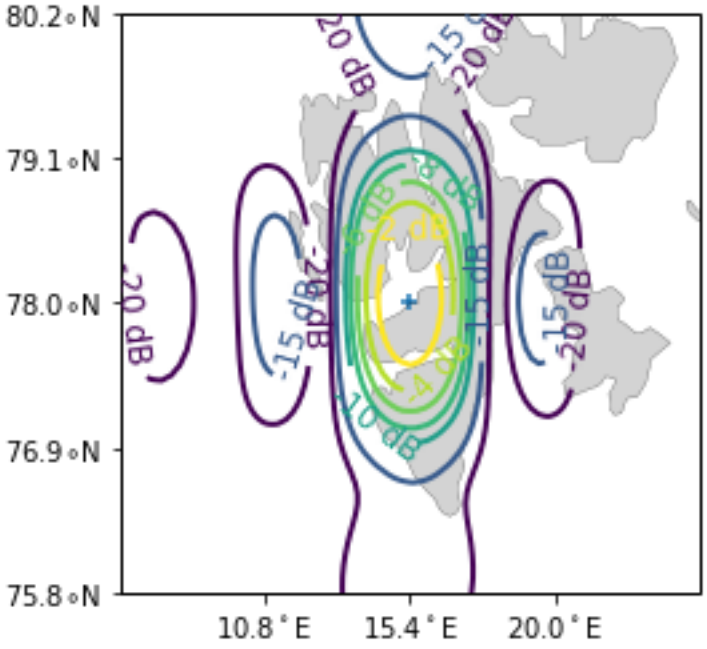

Figure V.A-3. Capella X-Band Payload Downlink Ground-Projected Gain Contours for 400km Altitude

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:

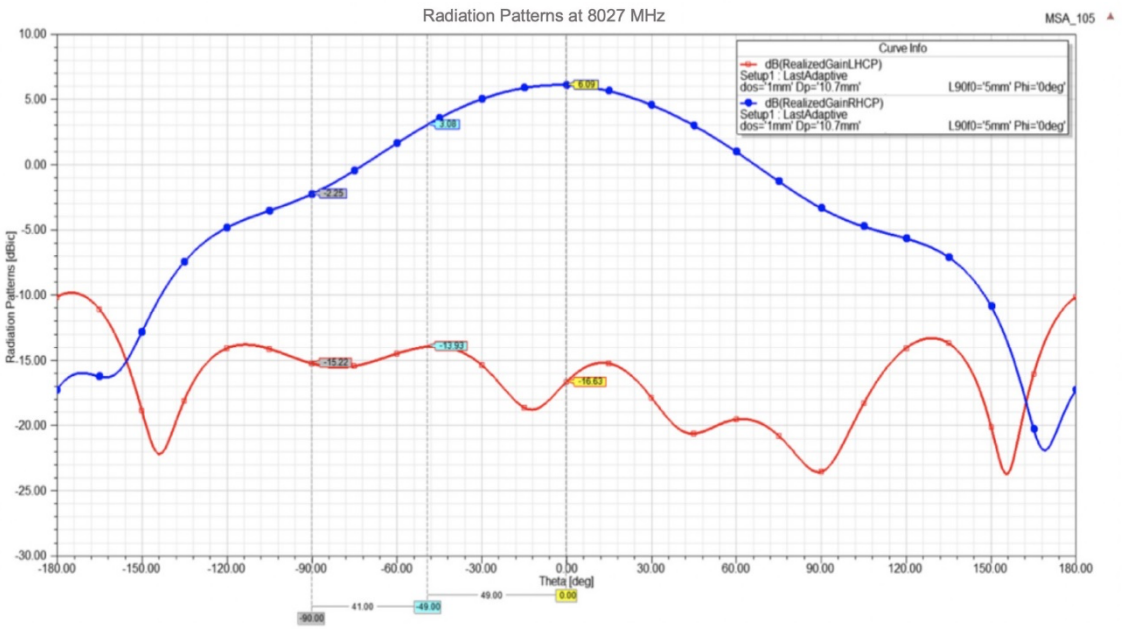

Figure V.B-1. Capella X-Band TT&C Downlink Gain Pattern

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:

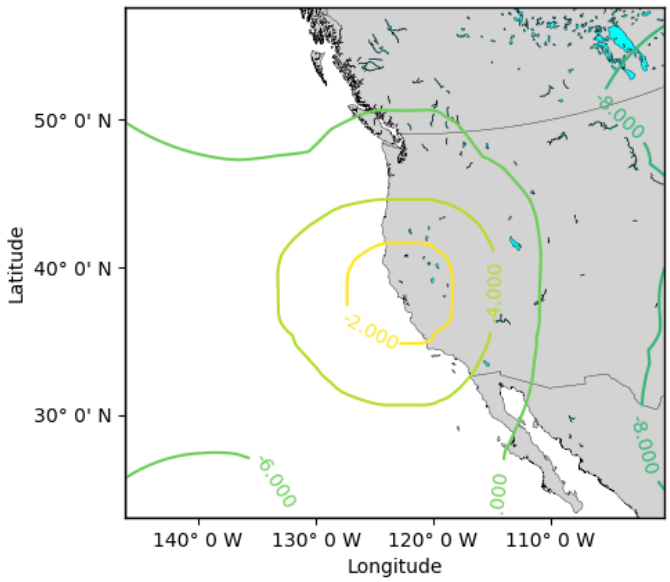

Figure V.B-2. Capella X-Band TT&C Downlink Ground-Projected Gain Contours for 575 km Altitude

Figure V.B-3. Capella X-Band TT&C Downlink Ground-Projected Gain Contours for 400 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:

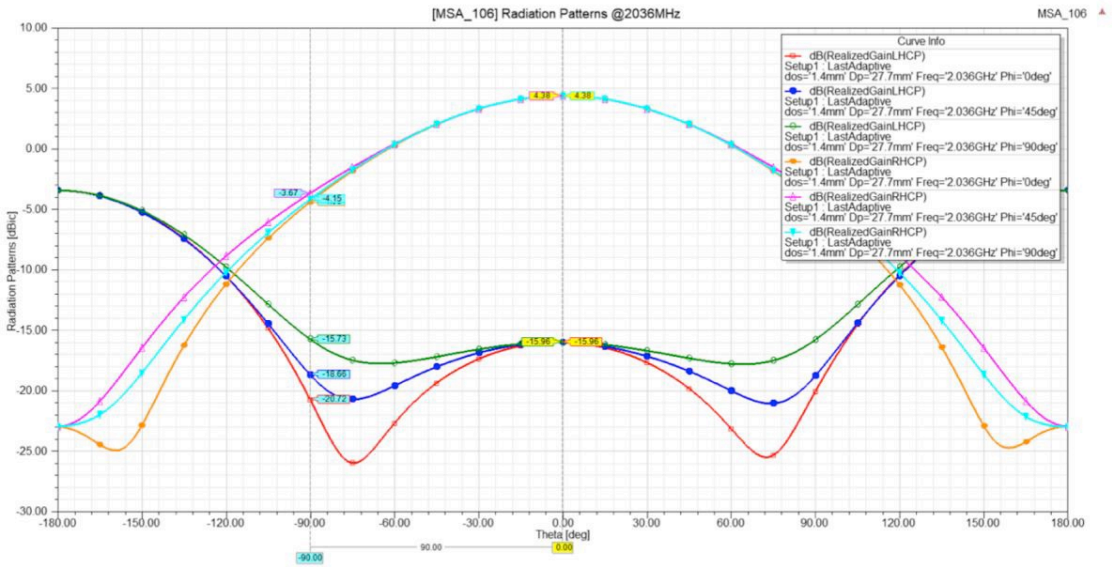

Figure V.C-1. Capella S-Band TT&C Uplink Gain Pattern

D. X-Band SAR Antenna

The Capella X-Band SAR beam will have a maximum EIRP of 78.0 dBW with a channel bandwidth of 10 to 700 MHz, using linear polarization, with the gain pattern shown in Figure V.D-1 below:

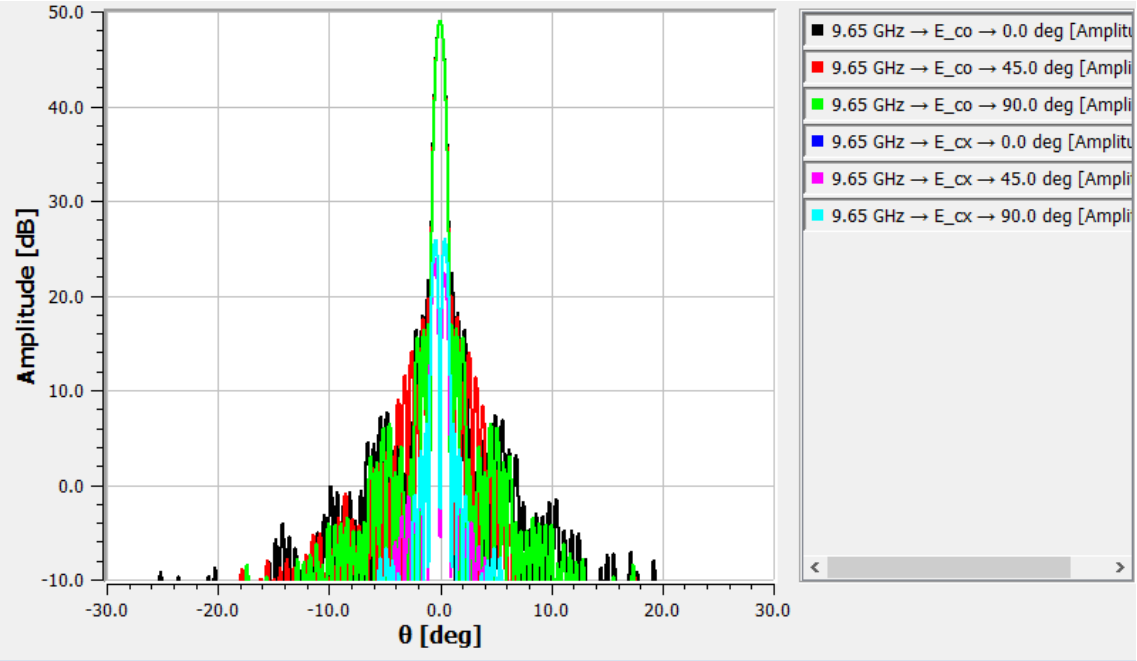

Figure V.D-1. Capella X-Band SAR Gain Pattern

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:

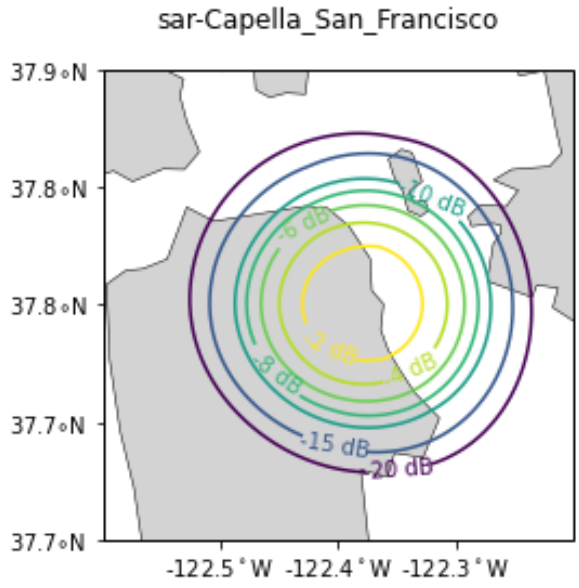

Figure V.D-2. Capella X-Band SAR Gain Contour at 575 km

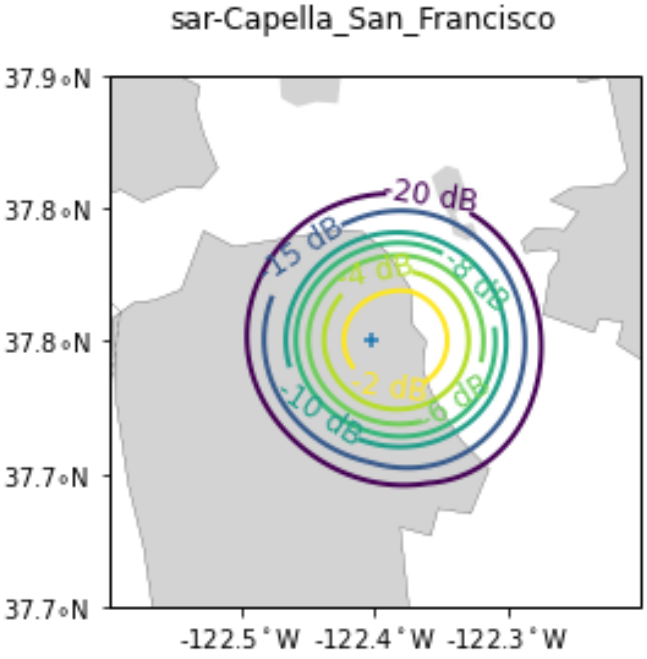

Figure V.D-3. Capella X-Band SAR Gain Contour at 400 km

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.

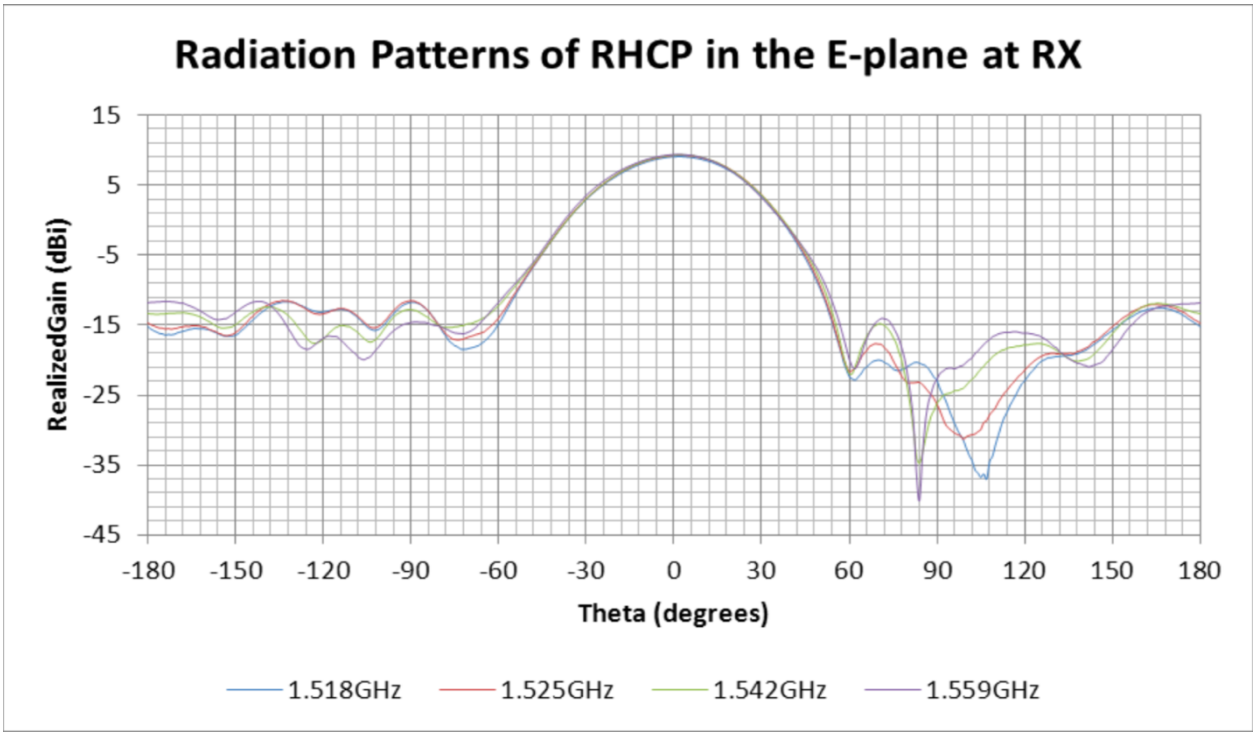

Figure V.E-1. Capella Space-to-Space Uplink E-Plane Gain Pattern

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

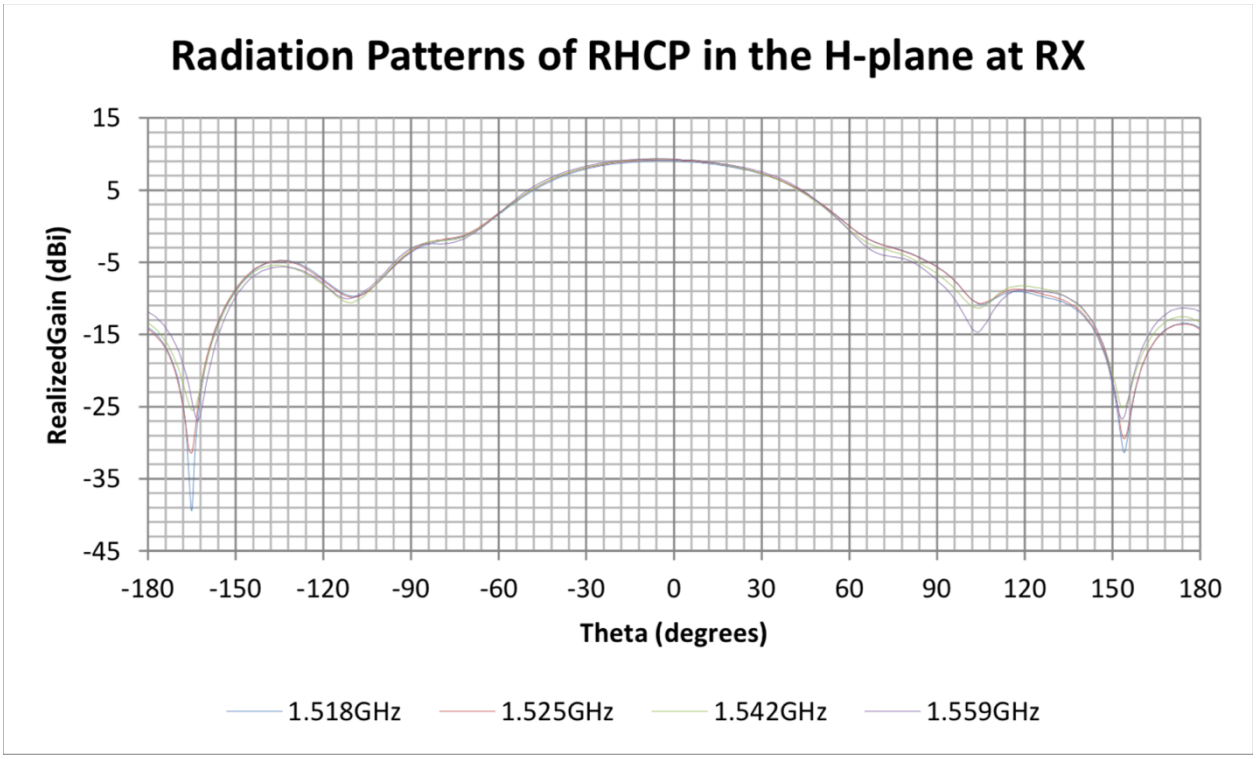

Figure V.E-2. Capella Space-to-Space Uplink H-Plane Gain Pattern

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.

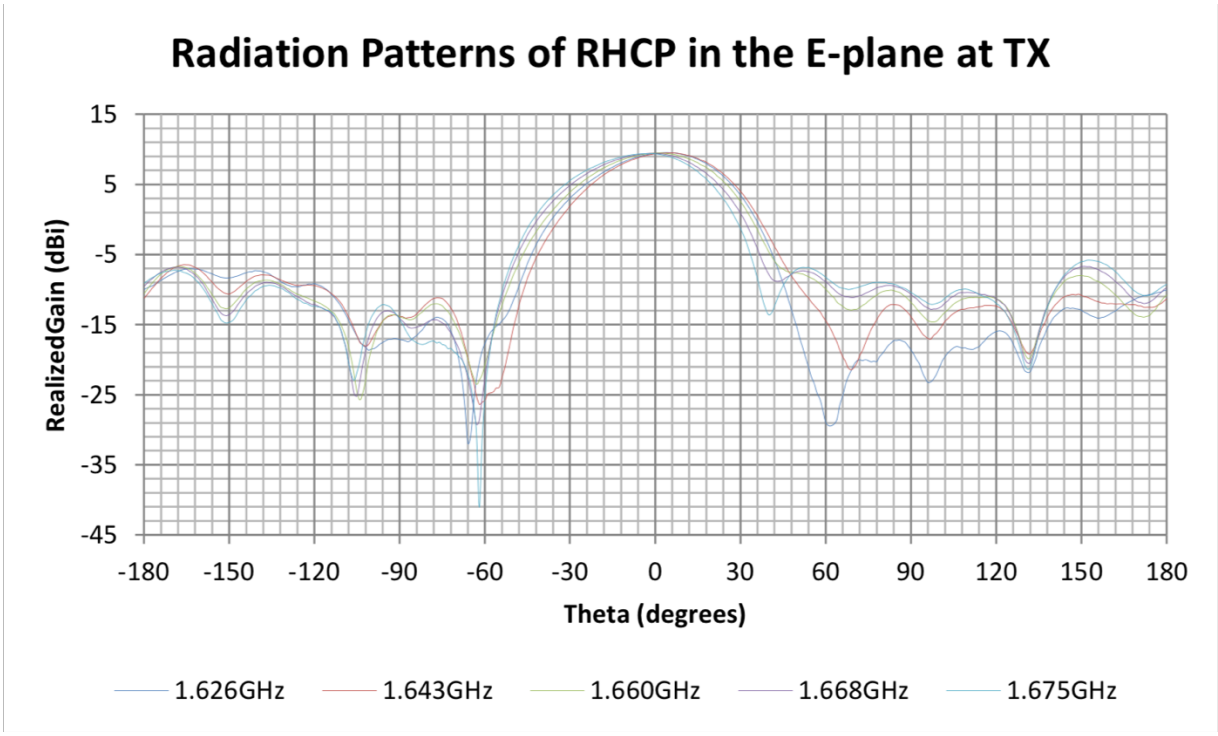

Figure V.F-1. Capella Space-to-Space Downlink E-Plane Gain Pattern

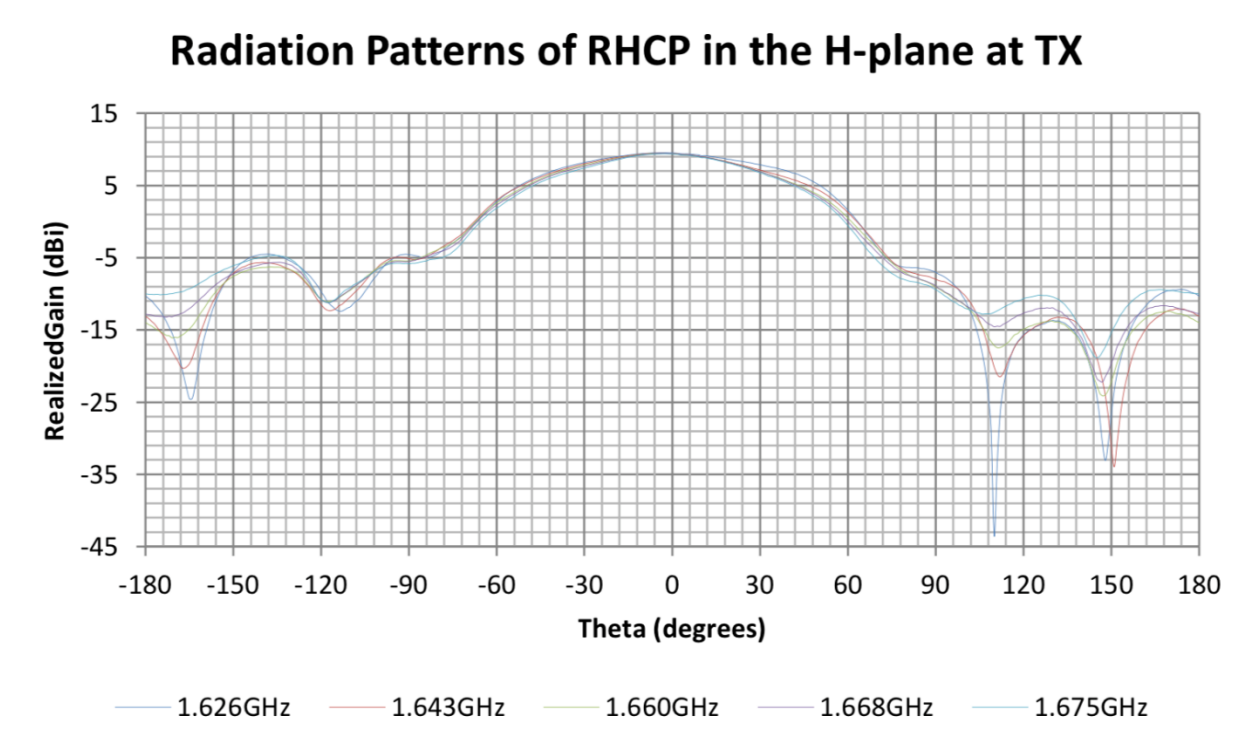

Figure V.F-2. Capella Space-to-Space Downlink H-Plane Gain Pattern

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.

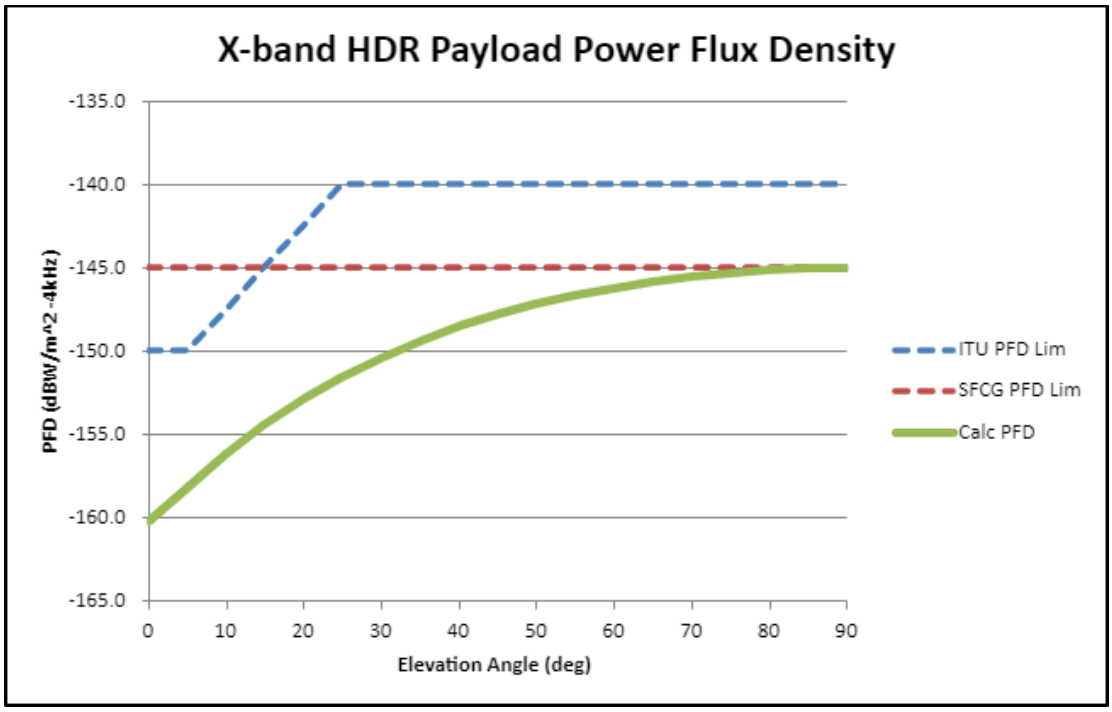

Figure VII.A-1. Capella X-Band Payload Downlink PFD at the Earth's Surface

[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). At altitudes below 450 km, the Capella satellites will reduce EIRP in the X Band to ensure continued compliance with these limits. The Capella telemetry beacon may continue to operate at altitudes below 400 km to ensure the continued trackability of the spacecraft before demise, but the EIRP of this beacon will continue to be adjusted as necessary to ensure ongoing compliance with PFD limits.

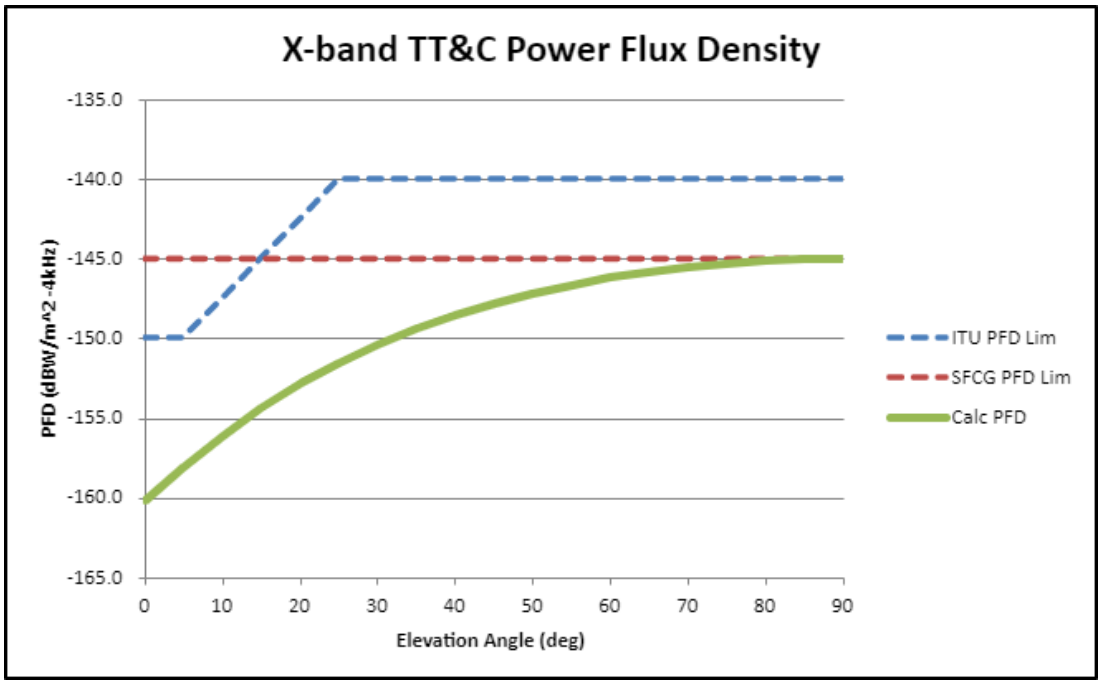

Figure VII.A-2. Capella X-Band TT&C Downlink PFD with adjusted EIRP at the Earth's Surface

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

satellite 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	625	Km	Worst-case, highest orbit altitude
GEO Altitude	35786	Km	
Distance to GEO	35161	Km	
Path Loss	-201.66	dB	
RX Pwr Flux Density (4 kHz)	-181.65	dBW/m^2	
Requirement	-174	dBW/m^2	Per ITU Radio Regulation No. 22.5
Margin	**7.65**	**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	625	km	worst-case, highest orbit altitude
GEO Altitude	35786	km	
Distance to GEO	35161	km	
Path Loss	-201.46	dB	
RX Pwr Flux Density (4 kHz)	-182.85	dBW/m^2	
Requirement	-174	dBW/m^2	Per ITU Radio Regulation No. 22.5
Margin	**8.85**	**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	400.00	Km	Worst-case
Antenna Offset	0.00	Deg	Worst-case, DSN station at boresight
Pointing Loss	0.00	dB	
Space Loss @ 8400 MHz	-162.97	dB	
Total Path Loss	-162.97	dB	
DSN Earth Station Antenna Gain	74.00	dB	Per ITU-R SA.1157-1
Received Interference PSD @ 8.4 GHz	-228.95	dBW/Hz	
Protection Criterion	-221.00	dBW/Hz	Per ITU-R SA.1157-1
Margin	**7.95**	**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)	-56.96	dBW/Hz	
Spectral Roll-off @ 8.4 GHz (dBc)	-90	dBc	Measured noise floor
X-Band Downlink PSD @ 8.4 GHz	-146.96	dBW/Hz	
Slant Range	400.00	km	Worst-case
Antenna Offset	0.00	deg	Worst-case DSN station at boresight
Pointing Loss	0.00	dB	
Space Loss @ 8400 MHz	-162.97	dB	
Total Path Loss	-162.97	dB	
DSN Earth Station Antenna Gain	74.00	dB	Per ITU-R SA.1157-1
Received Interference PSD @ 8.4 GHz	-235.93	dBW/Hz	
Protection Criterion	-221.00	dBW/Hz	Per ITU-R SA.1157-1
Margin	**14.93**	**dB**	

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

B. Power Flux Density Calculations in the 9900-10400 MHz Band

Table 21-4 of the ITU-R Radio Regulations Art. 21.16 specifies the following PFD limits applicable to EESS emissions in the 9900-10400 MHz band:

- −113 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5.7 degrees above the horizontal plane;
- $-109 + 25\log(d - 5)$ dB(W/m^2) in any 1 MHz band for angles of arrival d (in degrees) between 5.7 and 53 degrees above the horizontal plane;
- −66.6 dB(W/m^2) in any 1 MHz band for angles of arrival between 53 and 90 degrees above the horizontal plane.[5]

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

As shown in Figures VII.A-1 and VII.A-2 below, Capella will comply with these PFD limits.[6]

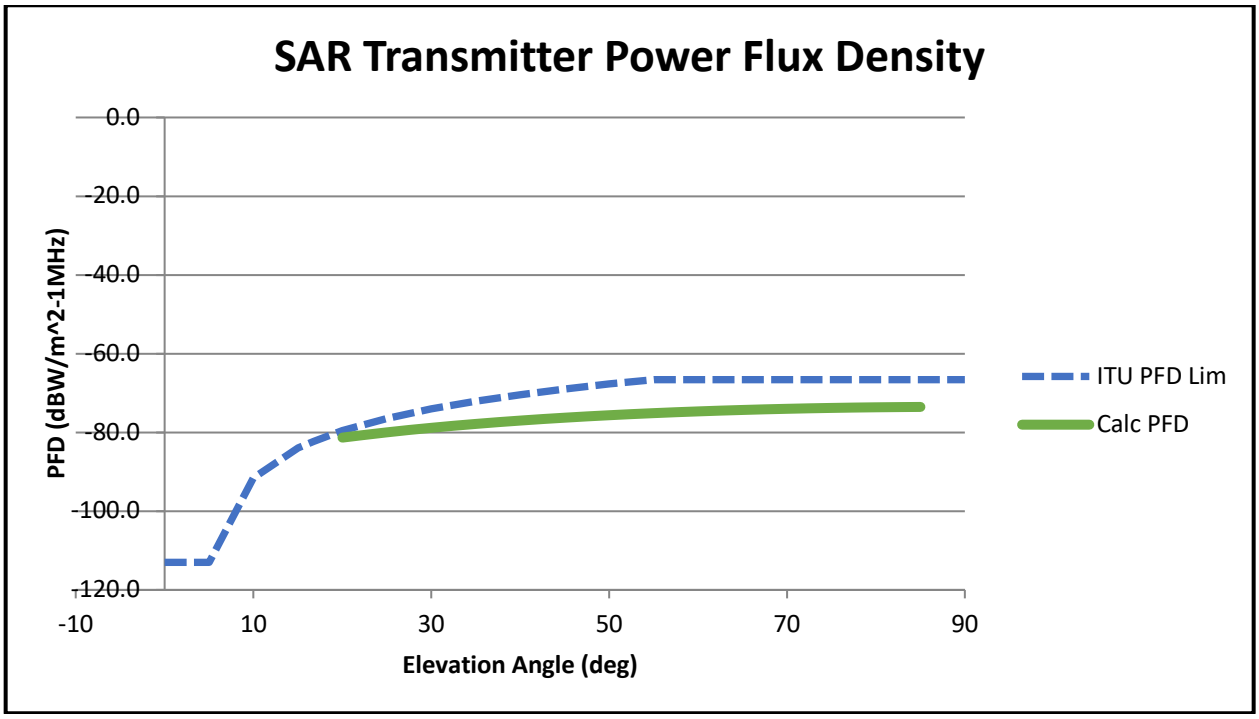

Figure VII.B-1. Capella X-Band (9.9-10.4 GHz) SAR PFD at the Earth's Surface

C. 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.

D. Other Sharing Considerations in the 9300-9900 MHz and 9900-10000 GHz Bands

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. Outside the United States, the same is true in the 9900-10000 GHz band, although the United States has not

[6] Capella will operate the SAR transmitter only within the 20-85 degree elevation range depicted in Figure VII.B-1.

yet adopted the primary allocation for EESS (active) in this band. As demonstrated below, the Capella system will not cause harmful interference to terrestrial radiolocation operations in these bands, as required by ITU-R Table of Allocations Note 5.474D.

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 transmit at a radiated power of 79 dBW— greater than the radiated power of the Capella radar (EIRP of 78 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 each of 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 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 (78 dBW) is greater than that of many terrestrial emitters, the power flux density incident on a terrestrial receiver will be –45 dBW/m^2 at a distance of 400 km (the lowest operating altitude for a Capella radar). For an authorized marine navigation radar that is 1 km from the terrestrial receiver, the power flux density incident on the terrestrial receiver will be –7 dBW/m^2. As a result, the power flux density of the Capella radar transmitter at a terrestrial receiver will be 38 dB lower than authorized marine navigation radars.

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.[7] Capella satellites are not 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.

E. 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

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

Capella satellite. As with its other operations, Inmarsat will assign channels to Capella 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.

F. Protection of Radioastronomy Sites

ITU-R Rec. RS.2066 provides recommendations for protecting radioastronomy sites operating at 10.6 – 10.7 GHz to ensure that sensitive radioastronomy equipment is not damaged by receiving transmissions from synthetic aperture radar systems in the 9.6 GHz band. Capella will protect the sites listed in Annex 2 of RS.2066 by implementing exclusion zones described in Annex 1.

G. Protection of Ground Stations in the Space Research Service

ITU-R Rec. RS.2065 provides an approach for preventing harmful interference to space-to-Earth links in the Space Research Service ("SRS") at 8.4-8.5 GHz from SAR transmissions in the 9.6 GHz band. As these SRS transmissions are approximately 1 GHz lower than Capella's SAR transmissions, harmful interference to these SRS operations is, on its face, highly unlikely. Indeed, Capella's satellites will typically operate at a higher altitude or lower power than each of the example SAR systems described in RS.2065.

Nonetheless, to further minimize the probability of any adverse impact to SRS links, Capella will pursue a combination of mitigation measures described in Annex 2 of that recommendation. Capella will also avoid transmitting in the vicinity of any involved SRS site in

the event that Capella is informed of any critical events, as described in that recommendation, or space emergencies.

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 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 is committed to maintaining the safety of the space environment, designing its satellites to maximize their reliability, minimize the risk of collision on orbit or during the deorbit process, and ensure that its satellites fully demise upon their reentry into the Earth's atmosphere.

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's spacecraft will not expel any other matter besides the xenon used as fuel during thrust events. Capella has also considered 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 a collision using NASA's Debris Assessment Software (DAS v.3.2.3) and has determined that the Capella satellites will be compliant with every NASA standard. The probability of damage from a small object at the worst-case altitude of 625 km is 0.005773, well 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 uses human-in-the-loop collision avoidance procedures. Conjunction Data Messages are assessed to determine if a maneuver is required and potential maneuvers are screened for safety and executed only if it is safe to do so. The results of maneuvers are monitored to determine potential subsequent steps. Capella's collision avoidance scheme has been used successfully on orbit for several years.

Capella has completed an ODAR Report for the spacecraft described in this application, which is attached as an appendix to this application.

Moreover, Capella is undertaking steps to address even this extremely remote possibility of collision by incorporating redundancy, shielding, separation of components, and other physical characteristics into the design of its satellites. 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 has designed 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 Capella satellites into energy that could fragment them. 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. For pressure system design, the propulsion system manufacturer uses a minimum safety factor of 1.5 and as such, all parts and components on the high-pressure side have been proof tested to a minimum of 1.5 times the maximum expected operating pressure. The tank is designed to contain up to 6,300g of xenon at the maximum operating temperature of 45°C —an inert gas—but will

actually be filled with only 4,200g, limiting the stored pressure. The tank temperature is not expected to exceed 45°C on orbit.

C. Safe Flight Profiles

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 0.00044—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. 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 to the 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 45 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 United States Space Force 18th Space Control Squadron (or any successor entity). Following deployment, Capella will actively identify and track its satellites using a network of ground stations that will establish contact with them. Capella certifies that its space stations will have unique telemetry markers allowing it to be distinguished from other satellites or space objects.

Because Capella's satellites will be larger than 10 cm in its smallest dimension, it is 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 any 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 any 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. 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 625 km (worst-case), nominal end-of-life configuration, and using the highly conservative solar-flux predictions included by default with the DAS software, atmospheric re-entry is expected to occur in approximately 11 years. However, as Capella has noted, this solar cycle has seen dramatically

greater solar flux than NOAA and others have predicted in their space weather models.[8] If configured to use more realistic solar-flux data, DAS would predict re-entry after only approximately 4 years. In addition, Capella commits to taking active steps to ensure that it remains in compliance with the 6-year deorbit obligation in the event that the current solar cycle moderates, slowing the satellites' natural orbital decay. Capella will monitor space-weather conditions on an ongoing basis to ensure that Acadia-1 and -2 remain in compliance with the 6-year deorbit obligation. This includes limiting orbit raising maneuvers as necessary to ensure compliance if the solar-flux environment becomes unfavorable for a timely deorbit from higher altitudes. Capella will also continue to assess whether any other operational steps or restrictions may be needed to ensure timely deorbit. Capella will monitor its satellites' propellant reserves to ensure that Acadia-1 and -2 are able to perform the necessary maneuvers to deorbit within six years in light of the evolving solar cycle.

Capella has also conducted a re-entry risk analysis using DAS. The spacecraft were modeled to a level of fidelity that included all spacecraft subsystems. As modeled, DAS indicates the entirety of each 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 zero.

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

[8] *See* Letter from Paul Caritj, Counsel to Capella Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20220919-00111 (filed Dec. 8, 2022).

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/ *Christian Lenz*

Christian Lenz
Chief Technology Officer
CAPELLA SPACE CORP.

March 7, 2023

Date