

Before the
Federal Communications Commission
Washington, DC 20554

Application of

Capella Space Corp.

For Authority to Launch
and Operate a Non-Geostationary
Orbit Satellite System in the Earth
Exploration Satellite Service

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File No. _____

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Operate a Non-Geostationary Orbit Satellite System in the Earth
Exploration Satellite Service**

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**Application of Capella Space Corp. for Authority to Launch and Operate a
Non-Geostationary Orbit Satellite System in the Earth Exploration
Satellite Service**

Capella Space Corp. (“Capella”) hereby requests authority to launch and operate three small satellites in low-Earth, non-geostationary orbit (“NGSO”) for provision of Earth-Exploration Satellite Service (“EESS”). A completed Form 312, accompanying Schedule S, Technical Attachment, and Waiver Request are included with this application to provide the information required by the Commission’s rules. This application is submitted under the Commission’s streamlined licensing procedures governing small satellites.¹

I. Background and description of services

Capella Space Corp. is a privately held company headquartered in San Francisco, California with an additional office in Louisville, Colorado. Capella was founded in 2016 to provide space-based earth observation and analytics to organizations around the globe, using synthetic aperture radar (“SAR”) from a constellation of small satellites in low earth orbit (“LEO”). Since its founding in 2016, Capella has developed and launched its first experimental satellite, dubbed “Denali,” in late 2018; has validated its SAR payload using both Denali and multiple experimental airborne collection campaigns; and has raised close to \$80M in venture funding. 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.

¹ 47 C.F.R. 25.122. *See also Streamlining Licensing Procedures for Small Satellites*, 34 FCC Rcd 13077 (2019) (“*SmallSat R&O*”).

Capella has been awarded multiple phase 1 and phase 2 Small Business Innovation Research grants through the U.S. Air Force and contracts with the National Reconnaissance Office, Defense Innovation Unit, National Geospatial-Intelligence Agency and U.S. Navy, all in preparation for deployment of its commercial SAR constellation. These specific U.S. government customers, along with commercial and allied foreign government users worldwide, have reviewed Capella's plans and capabilities and are eagerly awaiting the deployment of its full constellation of satellites and delivery of SAR imagery. Capella was granted a NOAA license for the deployment of its constellation and has been working diligently with NOAA in the implementation and adherence to the stipulations of this license, including successful completion of a Data Protection Plan approved by NOAA's compliance regulators.

Capella has already obtained Commission authorization to launch and operate two of the three satellites described in this application—Capella-2 and Capella-3—on an experimental basis.² Capella-2 successfully launched on August 30, 2020, and expects to complete on-orbit checkout in October 2020. Capella-3 is scheduled for launch in December 2020. The Capella-4 satellite, the third satellite described in this application and the only one not already authorized under an experimental license, will share virtually all pertinent radiofrequency and orbital characteristics with Capella-3.³ Capella-4 is also scheduled to launch in December 2020.

Therefore, Capella respectfully requests that the Commission grant this application expeditiously to allow Capella to begin commercial operations. Our federal government

² See Experimental Authorization WL2XAD (granted June 26, 2020); Experimental Authorization WJ2XJE (granted Aug. 31, 2018, modification granted Sep. 4, 2020).

³ These operations will differ only in one minor technical respect: as detailed in the Technical Attachment, Capella requests to use a different bandwidth for payload downlink than currently authorized by Capella's experimental licenses.

customers in particular are eagerly awaiting the deployment of these satellites and are ready to receive data at the earliest date possible.

II. Description of system facilities and operations

A. Space segment

The Capella small satellites are about the size of a household washing machine when launched. Once deployed on orbit, the satellites deploy a 3.5 m / 11.5 ft diameter circular reflector antenna, which serves as the primary SAR payload antenna. This SAR antenna has a directivity of 48.2 dB. The satellite mass at launch is just over 110 kg and includes propellant used for orbit maintenance and collision avoidance.

B. Orbital information

As detailed below, the Capella satellites described in this application will operate at an altitude of 525 km (+/- 50 km) at inclinations of 45 and 97.5 degrees. Capella intends to make use of so-called “ride share” launch opportunities offered by launch providers such as SpaceX, which can result in multiple potential LEO orbits for its small satellites. However, the information below describes the anticipated orbital characteristics resulting from currently scheduled launches (and, for the Capella-2 satellite currently in orbit, the actual orbital characteristics). Capella will inform the Commission if it anticipates any changes to these characteristics.

Satellites per Plane	1
Inclination	$45 \pm 7^\circ$
Orbital Period	$5,708 \pm 63$ secs
Apogee	525 ± 50 km
Perigee	525 ± 50 km
Argument of Perigee	N/A – Near Circular Orbit
Active Service Arc	Full Orbit
RAAN	$280^\circ \pm 5^\circ$

Table 1 — Plane 1 Orbital Parameters

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

Table 2 — Plane 2 Orbital Parameters

C. Spectrum

The Capella system 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 3 — Frequencies of Operation

As indicated 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. Space-to-space “uplink” transmissions to the Capella system and space-to-space “downlink” transmission to the Inmarsat system will occur pursuant to licenses held by Inmarsat. These inter-satellite communications will occur on channels dynamically assigned by the Inmarsat system and be used by Capella 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 system earth station, as would be required for other TT&C operations. A letter of support from Inmarsat is provided with this application. To facilitate these space-to-space communications, Capella seeks authority to communicate with all satellites on the Commission’s ISAT List.

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 relatively infrequently and with low PFD on the ground, further minimizing the probability of a worst-case geometric configuration while these systems are active.

D. Ground segment and operations

Capella has contracted with commercial ground station providers Kongsberg Satellite Services (“K-SAT”) and Amazon Web Services Ground Station (“AWS”), which operate ground stations around the world as a service, for both payload and TT&C communications with the Capella system. 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. Both K-SAT and AWS have obtained or are in the process of obtaining the necessary authorizations from regulators in their respective jurisdictions for communications with the Capella system.

Capella ground operations are controlled from its primary Mission Operations Center in San Francisco, California with a backup facility in Louisville, Colorado. In accordance with its NOAA license, Capella maintains a 24/7/365 operations hotline and on-call staff. Constellation monitoring is constant via automated and human systems allowing for quick reaction in response to technical or regulatory questions or concerns.

E. Launch schedule

Capella-2 was launched on August 30, 2020 on a RocketLab Electron launch vehicle from Mahia, New Zealand. Capella has contracted with SpaceX for launches of the Capella-3 and Capella-4 satellites in December 2020 on SpaceX Falcon 9 launch vehicles from the continental United States.

III. Small satellite certifications

Consistent with the requirements for streamlined treatment under Section 25.122, Capella hereby certifies that the space stations to be operated under the requested license meet the following criteria:

1. The space stations will operate only in non-geostationary orbit.
2. The total in-orbit lifetime for any individual space station will be six years or less.
3. The space stations will be deployed at an orbital altitude of 600 km or below, will maintain a propulsion system, and have the ability to make collision avoidance and deorbit maneuvers using propulsion.⁴
4. Each space station will be identifiable by a unique signal-based telemetry marker distinguishing it from other space stations or space objects.
5. The space stations will release no operational debris.
6. Capella has assessed and limited the probability of accidental explosions, including those resulting from the conversion of energy sources on board the space stations into energy that fragments the spacecraft.
7. The probability of a collision between each space station and any other large object (10 centimeters or larger) during the orbital lifetime of the space station is 0.001 or less as calculated using current NASA software or other higher fidelity model.⁵
8. The space stations will be disposed of post-mission through atmospheric re-entry. The probability of human casualty from portions of the spacecraft surviving re-entry and reaching the surface of the Earth is zero as calculated using current NASA software or other higher fidelity models.
9. Operation of the space stations will be compatible with existing operations in the authorized frequency bands. Operations will not materially constrain future space station entrants from using the authorized frequency bands.
10. The space stations can be commanded by command originating from the ground to immediately cease transmissions and the licensee will have the capability to eliminate

⁴ Although Section 25.122 requires only that proposed space stations be deployed at an orbital altitude of 600 km or below *or* be capable of making collision avoidance and deorbit maneuvers using propulsion to qualified for the requirements for streamlined processing under the Commission's small-satellite rules, Capella's satellites will satisfy both of these two alternative requirements.

⁵ Capella used DAS v2.1.1 for the showing included in the enclosed Technical Attachment. Capella has a request pending with NASA for access to the latest version of this software and will update its analysis when Capella gains access to that software.

harmful interference when required under the terms of the license or other applicable regulations.

11. Each space station is 10 cm or larger in its smallest dimension.

12. Each space station will have a mass of 180 kg or less, including any propellant.

IV. Spectrum use and sharing capabilities

Capella is committed to ensuring equitable sharing among all licensed co-frequency spectrum users. Capella satellites will operate in all frequency bands used in a manner that will avoid harmful interference. Capella has submitted a coordination agreement to NASA and other federal agencies in order to assure that critical services are not impacted by the operation of the Capella system. Also, Capella and the U.S. Air Force are participating in ongoing coordination discussions regarding Capella operations in the 8025-8400 MHz frequency band in order to assure that the U.S. Air Force systems in this band are not impacted by the Capella system. A more detailed discussion of compliance with all requirements for the avoidance of harmful interference is contained in the Technical Attachment.

A. X-band payload downlink

As described in the table below, Capella X-Band payload downlink will operate within the 8025-8400 MHz band. As noted above, Capella and the U.S. Air Force are in coordination discussions regarding Capella operations in the 8025-8400 MHz band and, in particular, Capella's authorized bandwidth, to ensure that Capella operations do not interfere with U.S. Air Force systems.

Frequency Range	8043.75 – 8381.25 MHz
Bandwidth	337.5 MHz
Center Frequency	8212.5 MHz
EIRP	26 dBW
Polarization	RHCP / LHCP

Table 4 — Payload downlink characteristics

B. S-Band TT&C uplink

As described in the table below, Capella S-Band TT&C uplinks will operate within the 2025-2110 MHz band with a maximum G/T of -23.4 dB/K, using RHCP polarization.

Frequency Range	2035.3 – 2036.7 MHz
Bandwidth	1.4 MHz
Center Frequency	2036 MHz
G/T	-23.4 dB/K
Polarization	RHCP

Table 5 — TT&C uplink characteristics

This link is used for command uplinks under the Earth Exploration Satellite Service (Earth-to-space) allocation. Non-Federal Earth-to-space transmissions may be authorized in the EESS services subject to such conditions as may be applied on a case-by-case basis.⁶ Uplink transmissions shall not cause harmful interference to Federal and non-Federal stations operating in accordance with the Table of Frequency Allocations. A coordination agreement has been submitted to NASA and other federal agencies to ensure that Capella uplinks do not interfere with critical systems of these agencies.

⁶ 47 C.F.R. § 2.106 n. US347.

C. X-Band TT&C downlink

As described in the table below, the Capella X-Band TT&C downlink will operate within the 8025-8400 MHz band with a maximum EIRP of 4.5 dBW in a 1.4 MHz channel, using RHCP polarization.

Frequency Ranges	8026.3 – 8027.7 MHz
Bandwidth	1.4 MHz
Center Frequency	8027
EIRP	4.5 dBW
Polarization	RHCP

Table 6 — TT&C downlink characteristics

A coordination agreement has been submitted to NASA and other federal agencies to ensure that Capella downlinks do not interfere with critical systems of these agencies.

D. X-Band SAR imaging system

As described in the table below, the Capella X-Band SAR beam will have a maximum EIRP of 76.0 dBW in a 600 MHz channel, using linear polarization.

Frequency Range	9300-9900 MHz
Bandwidth	600 MHz
Center Frequency	9600 MHz
EIRP	76.0 dBW
Polarization	Linear

Table 7 — SAR transmission characteristics

Capella plans to utilize the 9300-9900 MHz band for SAR imaging under the Earth Exploration-Satellite Service (active) allocation. This frequency band is currently being used by other similar

SAR systems, including the German TerraSAR-X satellite, the Italian COSMO-SkyMed system, the Finnish ICEYE satellites, and others in China and India. The Capella SAR system generates brief pulses using a very high directivity antenna – thus minimizing both the active time as well as the affected areas on the ground.

Capella’s analysis indicates that this SAR system will not cause any harmful interference to existing government, commercial, or scientific systems. Furthermore, a coordination agreement has been submitted to NASA and other federal agencies to ensure that Capella SAR operations do not interfere with critical systems of these agencies.

E. Space-to-space uplink

As described in the table below, Capella plans to use a space-to-space link between its satellites and the existing commercial Inmarsat geostationary constellation.

Frequency Ranges	1525.0 – 1559.0 MHz
Bandwidth	25-200 kHz
G/T	-18.6 dB/K
Polarization	RHCP

Table 8 — Space-to-space uplink characteristics

In this case “uplink” refers to the link from the Inmarsat GEO satellite to the Capella LEO satellite. The Capella GEO to LEO uplink will operate within the existing Inmarsat 1525.0-1559.0 MHz band, using RHCP polarization. These transmissions are approved and supported by Inmarsat (See Letter of Support) and fall within its currently licensed spectrum. Inmarsat will provide specific channel assignments dynamically consistent with its network operations.

F. Space-to-space downlink

With respect to space-to-space communications between Capella satellites and the existing commercial Inmarsat geostationary constellation, “downlink” refers to the link from the Capella LEO satellite to the Inmarsat GEO satellite. As described in the table below, the Capella LEO to GEO downlink will operate within the 1626.5-1660 MHz band with a maximum EIRP of 8.5 dBW and up to 200 kHz bandwidth, using RHCP polarization. (The operational bandwidths change between 25, 50, 100, and 200 kHz, depending on data rate.)

Frequency Ranges	1626.5 – 1660.0 MHz
Bandwidth	25-200 kHz
EIRP	8.5 dBW
Polarization	RHCP

Table 9 — Space-to-space downlink characteristics

These transmissions are approved and supported by Inmarsat and fall within its currently licensed spectrum. Inmarsat will provide specific channel assignments dynamically consistent with its network operations.

V. Grant of the application is in the public interest

Grant of this application will promote the public interest by facilitating the near-term deployment of newly developed SAR technology for the provision of low-cost, high-value strategic imaging services. The proposed constellation of Capella small satellites will take advantage of recent advances in satellite technology as well as the Commission’s new streamlined small satellite rules to bring new capabilities into the marketplace in the service of commercial, scientific, and government applications and users.

Because Capella's SAR satellites can see through clouds and at night, they offer complete global visibility, enabling vital decisions across dozens of industries from defense to infrastructure saving money, time and lives. Our space-based radar can detect sub-meter changes on the surface of the Earth. Reliably delivered, this information can protect the integrity of infrastructure, ensure food security, and help speed aid in times of crisis. Traditionally, SAR data and information derived from it has been very expensive, hard to acquire, procured by large satellites and used mostly by the most privileged governments. Developing much smaller SAR satellites not only enables Capella to put assets into orbit faster, cheaper and in the ideal spatial location to deliver comprehensive global coverage, but also provides access to the resulting information to a wider group of potential end users, including for-profit, not-for-profit, and government institutions globally. There are any number of commercial industries that would benefit from such data. For example:

Infrastructure monitoring. Infrastructure failure is often catastrophic. For operators of airports, dams, power plants, roads and bridges across the world, preparedness is key – and the key to preparedness is access to relevant and timely data. Capella's SAR Constellation can detect minute, sub-meter changes in infrastructure at, or even below, the surface of the Earth from space, allowing operators to monitor the integrity of their mission-critical infrastructure and maintain infrastructure more cost-effectively.

Agriculture. Capella will enable farmers to access SAR information created specifically for their needs to assess viability and yield of their own harvests, as well as measure and track global supplies, from seed to distribution. Because its data is based on satellite radar, Capella will reliably monitor many thousands of acres and can measure soil moisture and inundation, detect where crops have been damaged, and provide a reliable and up-to-date source for insurance claims.

Disaster response and recovery. In the event of a natural disaster, first responders require timely and accurate information to determine the nature of the situation and how best to react to it. Without such information, authorities will not have the full complement of tools they need to determine the best strategy in the case of a flood, wildfire, earthquake, or tsunami. Within just hours after such a disaster, Capella can provide high-resolution SAR imagery of the affected area, regardless of the time of day, cloud cover, or obscuring smoke.

Capella will help to make valuable SAR data available for an ever-expanding list of use cases applied anywhere in the world.

In addition, the SAR Constellation was designed from the ground up to achieve these important objectives in a way that minimizes any possibility of interference to other licensees (including both satellite and terrestrial operations), minimizes the risk of orbital debris, and minimizes any possibility of accidental collision. In addition to complying with the applicable ITU spectrum sharing rules, the SAR Constellation was designed to comply with industry standards.

The SAR constellation also features robust protections against the accidental release of orbital debris. In addition to “safeing” all reservoirs of stored energy as soon as the operational need for them has passed, Capella’s satellites will not include any store of chemically volatile propellant, instead relying on a relatively inert pressurant and an RF Ion engine, which uses ionized Xenon as its propellant. The SAR Constellation’s orbital characteristics and the aerodynamic design of its spacecraft form an additional layer of protection. At Capella’s requested orbital altitudes, satellites in the SAR Constellation will rapidly re-enter the Earth’s atmosphere on their own due to residual atmospheric drag – a process that will be greatly accelerated by the very large deployed antenna if not counteracted by the onboard propulsion system.

Capella has built a coalition of investors, partners, and civil and military users that are working diligently to bring world class SAR capabilities to market in 2020. Capella is leveraging U.S. technology, expertise, and funding while at the same time maintaining the highest level of system integrity and accountability — as is shown by the close collaboration with NOAA, NASA, the U.S. Defense Innovation Unit, the U.S. Air Force, the National Reconnaissance Office, the National Geospatial-Intelligence Agency, and the U.S. Navy.

Capella SAR constellation will provide valuable new services for customers in the United States and around the world, enabling government and private entities to make more informed decisions on a wide range of business and life-safety issues. Accordingly, an expeditious grant is in the public interest.

VI. Other matters

A. Related FCC authorizations

Capella was issued an experimental radio authorization under Call Sign WJ2XJE on August 31, 2018 (*see* OET ELS File No. 0066-EX-CN-2018). This license was used in the deployment and operation of Capella’s first satellite, called “Denali” in 2018. Capella has since sought and obtained a modification of that license (*see* OET ELS File No. 0029-EX-CM-2020) to permit experimental operation of Capella-3 as well as an additional experimental authorization for Capella-2 under Call Sign WL2XAD, which was launched on August 30, 2020 (*see* OET ELS File No. 0228-EX-CN-2020). These two licenses were obtained with the intent to operate these two spacecraft on an experimental basis prior to obtaining a commercial license and starting commercial service under the small satellite licensing process.

Additionally, Capella has been engaged in a testing program of SAR technology using aircraft mounted sensors flying at altitudes of up to 10,000 feet at several locations in the United States (*see, e.g.*, OET ELS File Nos. 0903-EX-ST-2019 and 0203-EX-ST-2020).

B. NOAA authorization

Capella was issued an updated license to operate a private remote sensing space system by NOAA’s National Environmental Satellite, Data, and Information Service on July 20, 2020. The NOAA license permits Capella to operate the private constellation of up to 44 SAR satellites

subject to the conditions and terms of the license. The NOAA license includes findings that Capella satisfies the requirements for compliance and monitoring, will comply with the national security concerns of the United States, and will comply with all applicable international obligations and foreign policies. Capella has successfully completed and passed multiple quarterly NOAA audits since early 2019.

C. ITU compliance

Capella is aware that, as a result of the actions taken at the 1998 Plenipotentiary Conference, as modified by the ITU Council in 2005, the ITU now charges processing fees for satellite network filings. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU. Capella confirms that it is aware of this requirement and accepts responsibility to pay any ITU cost recovery fees associated with this application. Invoices for such fees may be sent to the contact representative listed in the accompanying FCC Form 312.

Pursuant to 47 C.F.R. §§ 25.111 for space systems, it is understood that the Commission will submit filings to the ITU on behalf of Capella pursuant to international obligations for the coordination and registration of space network systems. Capella is providing the Commission the appropriate electronic files for submission to the ITU along with this application.

VII. Conclusion

For the foregoing reasons, and for the reasons set forth in the accompanying materials, Capella requests that the Commission find that granting Capella operating authority for the SAR Constellation proposed herein would serve the public interest, and issue such grant expeditiously.

Respectfully submitted,

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