Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Momentus Inc.	)	File No. SAT-STA_____
	)	
Application for Special Temporary Authority	)	
to Launch and Operate an In-Space	)	
Transportation Spacecraft	)	
	)	

APPLICATION FOR SPECIAL TEMPORARY AUTHORITY

Tony Lin
George John
Hogan Lovells US LLP
555 13th Street, NW
Washington, DC 20004
+1-202-637-5795

Counsel for Momentus Inc.

Philip Hover-Smoot
Chief Ethics & Compliance Officer
Momentus Inc.
3050 Kenneth Street
Santa Clara, CA 95054
+1-415-254-1295

Dated: June 8, 2020

TABLE OF CONTENTS **Page**

Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Momentus Inc.	)	File No. SAT-STA-_____
	)	
Application for Special Temporary Authority to Launch and Operate an In-Space Transportation Spacecraft	)	
	)	

APPLICATION FOR SPECIAL TEMPORARY AUTHORITY

I. Introduction

By this application, Momentus Inc. ("Momentus") requests Special Temporary Authority, pursuant to 47 C.F.R. § 25.120, to launch and operate the Vigoride-1 ("VR-1") non-geostationary orbit spacecraft in low-Earth orbit and to transport and deploy multiple, separate customer payloads at a specified final orbital destination. VR-1 will operate in the S-band (2025-2110 MHz) for Space Operations (Earth-to-space) and in the Ultra High Frequency ("UHF") band (400.15-401 MHz) for Space Operations (space-to-Earth). VR-1 is expected to be deployed from a Space Exploration Technologies Corporation ("SpaceX") Falcon-9 launch in December 2020, and the mission is expected to have a duration of 180 days, *i.e.*, from December 2020 to June 2021.

Momentus is a private U.S. company headquartered in Santa Clara, California. Momentus is engaged in the design, construction, and operation of in-space transportation spacecraft. Since its founding in 2017, Momentus has brought together a team of aerospace professionals, drawn from throughout the industry, united with the singular goal of changing how the world thinks about space transportation infrastructure. Through its revolutionary Vigoride spacecraft, each capable of transporting and delivering small satellites to tailored

orbital locations, Momentus will provide efficient and inexpensive "connecting flights" in space. The ability to customize orbits using Vigoride spacecraft empowers small satellite operators by enabling greater and lower-collision risk use of all orbits, including high-density orbits. Additionally, introducing the orbit flexibility of the Vigoride spacecraft into the existing commercial rideshare launch market can accelerate commercial space station deployments by expanding the orbital reach of existing launches, thereby increasing total ridership and contributing to lower launch prices. Cheaper, faster and smarter commercial space transportation has the capability to fundamentally change how space operators interact with on-orbit infrastructure. For all of these reasons, Momentus submits that the public interest would be served by grant of the application.

II. System Description

A. General System Descriptions

1. Vigoride VR-1 Spacecraft

The Vigoride spacecraft is a self-propulsive, free-flying spacecraft designed to transport and deploy customer payloads. The Vigoride spacecraft is capable of the transportation and deployment of dozens of individual payloads. For the initial mission, Vigoride VR-1 will be transporting five (5) individual payloads (individually, "Payload 1" through "Payload 5," and collectively, the "Payloads"), on behalf of four (4) customers (collectively, the "Customers"). Table 1 below provides a summary of the payloads and customer information.

Payload:	**Launched on behalf of:**	**Licensing Jurisdiction:**	**Size**	**Mass**
AURORASAT[1]	Aurora Propulsion Technologies Oy	Finland	1.5U	2.0kg

[1] AuroraSat has onboard propulsive capability.

LABSAT	SatRevolution	Poland	3.0U	4.0kg
STEAMSAT[2]	Steamjet Space Systems Ltd.	United Kingdom	1.5U	1.8kg
SWIFTVISION	SatRevolution	Poland	3.0U	4.0kg
VZLUSAT-2	SpaceManic CZ s.r.o.	Czech Republic	3.0U	4.4kg

Table 1: VR-1 Customer Payloads

All Payloads are commercial customer satellites. Furthermore, each customer is contractually obligated to obtain all necessary authorizations for operation of its spacecraft prior to integration with VR-1 and the launch vehicle, and Momentus will confirm each authorization, both as part of its contractual arrangements with its customers and its contractual arrangement with the launch service provider. If necessary, and in order to meet the VR-1 launch schedule, Momentus may replace a customer spacecraft with a mass dummy. Any such mass dummies would simulate the mechanical interfaces and mass of the customer spacecraft and allow Momentus to conduct a technology demonstration. Momentus, however, would not deploy the mass dummy in orbit. The ability to replace any customer satellite with a mass dummy is key to the ongoing certification of the VR-1 mass properties to the launch service provider. For the avoidance of doubt, should a representative mass be substituted for a customer payload, that representative mass would not be deployed on orbit.

The spacecraft is propelled primarily by a novel microwave electrothermal thruster ("MET"), which uses non-toxic and low-pressurized water propellant to provide orbit transfers. Momentus' innovative technology and propulsion system recently won a NASA iTech award.[3]

---

[2] SteamSat has onboard propulsive capability.

[3] *See NASA iTech Winners Impress with Tech Ideas for use in Space, on Earth*, NASA, https://go.nasa.gov/365KB8N (last edited Jul. 16, 2019).

Additionally, earlier this year, Momentus successfully completed a Phase I SBIR contract in collaboration with the United States Air Force (AFWERX) and Air Force Research Lab (AFRL) to accelerate innovations for in-space transportation services and satellite upper stage technologies.

The VR-1 mission operations center is located at the company headquarters in Santa Clara, California. All primary telemetry and commanding will be handled through this facility, via commercial ground stations, using encrypted links. Additional information on the Ground Segment is in section B.4. below.

VR-1 has a planned launch on a Falcon-9 rideshare in December 2020. VR-1 will be affixed directly to the Falcon-9 and deployed into a targeted 525 km (±25 km) circular sun-synchronous orbit with approximately a ~98 degree inclination.[4] After separation from the launch vehicle, VR-1 will undergo commissioning and, upon completion, will deploy Payloads 1 through 5. Subsequent to payload deployment, VR-1 will conduct orbit-raising maneuvers to a targeted maximum 570 km circular sun-synchronous orbit with a ~98 degree inclination. *See* Table 3 below (summarizing the relevant orbital parameters for the Payloads and VR-1).

As an integral part of the orbit raising concept of operations, Momentus will calculate and monitor propellant consumption and reserve a sufficient amount of propellant to ensure that VR-1 will be capable of conducting a final de-orbit maneuver, as discussed below. As demonstrated in the attached Orbital Debris Assessment Report ("ODAR"), a 570 km circular sun-synchronous orbit would be the worst-case scenario in the assessment of orbital debris risk, and VR-1 would re-enter the Earth's atmosphere in approximately16 years at that altitude.

---

[4] For the purposes of this application, Momentus assumed a 550 km maximum insertion orbit. In the event of the launch vehicle operator selecting an alternative insertion orbit, Momentus will notify the FCC.

Following demonstration of the orbit adjustment capabilities of the spacecraft, VR-1 will engage in de-orbit maneuvers to lower the perigee of the spacecraft to a target of 300 km altitude. Momentus intends to reserve propellant so that there will be sufficient propellant to execute the de-orbit maneuvers necessary to achieve the targeted 300 km perigee. At a 570 (maximum) x 300 km orbit, Momentus calculates that VR-1 will de-orbit within approximately 1 year. Naturally, if VR-1 does not reach a 570 km circular orbit, the VR-1 de-orbit period will be compressed further following completion of the de-orbit maneuver.

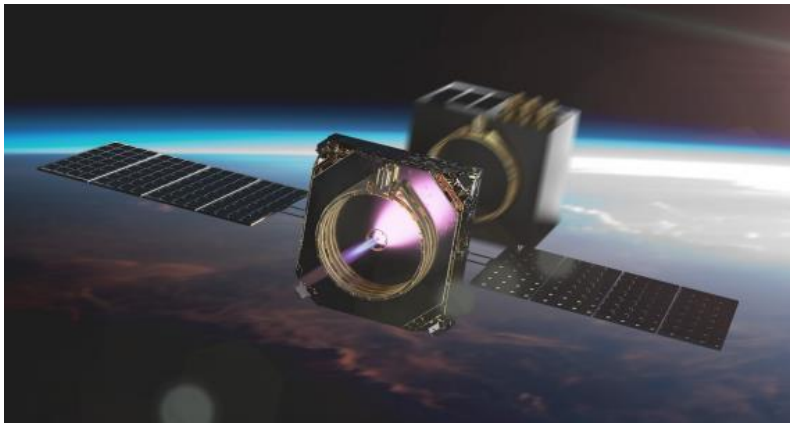

Figure 1: Artist's rendering of Vigoride deploying a customer spacecraft

2. The Momentus "Plaza Deck"

As part of the VR-1 mission, Momentus will also be deploying a number of additional payloads from a fixed "plaza deck," which will be permanently affixed to the Falcon-9.[5] The "plaza deck" does not require use of spectrum and is not subject to the spectrum request in this application. Nonetheless, Momentus is providing this information for completeness.

[5] VR-1 will also be deployed from the plaza deck.

On the "plaza deck," four ISILaunch cubesat deployers and three Alba Orbital PocketQube picosat deployers will be mounted. Customers being deployed from the "plaza deck" are all contractually obligated to obtain all necessary authorizations for operation of its spacecraft or payload prior to integration with the plaza deck and the launch vehicle. Similar to the customers for VR-1, Momentus will confirm each authorization both as part of its contractual arrangements with its customers and its contractual arrangement with the launch service provider. As of the filing of this application, all payloads currently under contract with Momentus to be deployed from the Plaza Deck can be found in Table 2, below.

Payload:	**Launched on behalf of:**	**Licensing Jurisdiction:**
ISILaunch Quadpacks (#4)	Innovative Space Logistics, B.V.	Netherlands
NUTSAT-0	Gran Systems Co., Ltd.	Taiwan
Alba PocketQubes (#3)	Alba Orbital Deutschland, U.G.	Germany

Table 2: Plaza Deck Payloads

B. Technical Specifications

1. Orbital Parameters

The VR-1 concept of operations is as follows[6]:

1. Launch vehicle arrives at initial orbit (maximum 550 km altitude circular sun-synchronous orbit)[7]
2. VR-1 separates from launch vehicle
3. VR-1 undergoes commissioning and preliminary testing

[6] VR-1 concept of operations is in addition to the deployment of Momentus customer payloads from the plaza deck.
[7] SpaceX reports a planned injection orbit of 525 km (± 25 km).

4. VR-1 conducts orbit raising maneuvers to second orbit (maximum 570 km circular sun-synchronous orbit, based on a planned 20 km raise from a notional maximum 550 km initial orbit)
5. VR-1 deploys Payloads 1 through 5
6. VR-1 performs detailed system functional testing
7. VR-1 conducts de-orbit maneuvers (targeting 300 km perigee)

	Insertion and Payloads 1 and 2 Orbit	**VR-1 Transfer Orbit**	**VR-1 End-of-Life Orbit**
Apogee Altitude	550 km (max)	570 km (max)	570 km (max)
Perigee Altitude	550 km (max)	570 km (max)	300 km[8]
Inclination	~98° (Sun-Synchronous)	~98° (Sun-Synchronous)	~98°
Period	96 mins	96 mins	90-96 mins
Argument of Perigee	N/A	N/A	N/A
Local Time of the Ascending Node (LTAN)	~21:00	~21:00	~21:00
Maximum De-Orbit Life	VR-1[9] 15 years	VR-1[10] 16 years	VR-1 1 years

Table 3: Orbital Parameters

2. Frequency Bands

VR-1 will operate in the S-band (2025-2110 MHz) for Space Operations (Earth-to-space) and in the UHF band (400.15-401 MHz) for Space Operations (space-to-Earth). *See* Table 4 below. The use of those frequencies will be primarily for telemetry, tracking, and command ("TT&C"). However, Momentus will also downlink imagery generated from an on-board

[8] The target perigee as a result of de-orbit maneuvers is expected to be 300 km.
[9] This is the de-orbit duration if VR-1 has a propulsion system *and* a solar array deployment failure after deployment from the launch vehicle.
[10] This is the de-orbit duration if VR-1 has a propulsion system failure after raising the orbit to 570 km altitude.

camera to confirm successful deployment of the Payloads.[11] Momentus is aware that there are federal and other operations in these frequency bands and intends to coordinate its proposed operations with affected operators prior to operations.

Criteria	Uplink (Earth-to-space)	Downlink (space-to-Earth)	Notes
Center Frequency	2075.0 MHz[12]	400.5 MHz	
Bandwidth	0.1 MHz	0.04 MHz	The wider uplink bandwidth accommodates forward error correction ("FEC").
Data Rate	38.4 kbps	38.4 kbps	Data rate is configurable from 1.2 kbps to 38.4 kbps.
Modulation & Coding	2-GFSK (no coding)	2-GFSK (no coding)	Links may include FEC.
Transmit Power	12W	1.8W	
Transmit Antenna	3.0 m (dish)	Dipole (2x monopoles)	
Transmit Antenna EIRP	43 dBW	-9.1 dBW	
Receive Antenna	Patch (7 dBiC)	Yagi (2.5λ)	
Receive Antenna G/T	-32.8 dB/K	-11.6 dB/K	

Table 4: Radio Frequency Plan

[11] Momentus is aware of the potential requirement to obtain a commercial remote sensing license from the National Oceanic and Atmospheric Administration ("NOAA") for the operations of imaging sensors and intends to comply with all necessary NOAA regulatory requirements. *See* 15 C.F.R. Part 960.

[12] Both the identified center frequencies are representative frequency channels. As a result of coordination with federal operators, Momentus may select another channel within the identified frequency bands for its operations.

3. Frequency Tolerance and Emission Limitations

Momentus will comply with the frequency tolerance requirements of 47 C.F.R. § 25.202(e) and the emission limitations of 47 C.F.R. § 25.202(f). In addition, VR-1's transmitter does not turn on automatically, and manual commands from the ground are required to initiate communications from the spacecraft. Accordingly, VR-1 complies with 47 C.F.R. § 25.207.

4. Ground Stations

For the VR-1 mission, Momentus intends to use Leaf Space S.r.l. ("Leaf Space"), via their "Leaf Key" ground segment as a service solution, as the ground segment provider. Leaf Space currently has four operational ground stations in Europe and plans to operate additional stations in other locations, including the United States. Leaf Space received a license from the Italian Ministry of Economic Development ("MISE") on April 4, 2020 to operate their Vimercate (Milan area) ground station in support of the VR-1 mission within the parameters described herein. Leaf Space is also planning to obtain a license for operation of the VR-1 spacecraft using an additional ground station located in Cork, Ireland. Communications between Momentus HQ and Leaf Space will be protected by levels of encryption appropriate to secure control over the VR-1.TT&C transmissions will be encrypted. Table 5 below identifies the ground stations from which Leaf Space plans to communicate with the VR-1 spacecraft.

Location	**Latitude (°N)**	**Longitude (°E)**	**Status**
Vimercate, Italy	45.59	9.36	Operational
Cork, Ireland	51.90	-8.48	Operational

Table 5: Ground Station

5. Microwave Electrothermal Thruster

VR-1 uses a radiofrequency generator that emits electromagnetic energy at a maximum theoretical power level of 40 watts (16.53 dBW) to operate the thruster. This generator uses a

gallium nitride solid-state device to efficiently produce this level of power output, which, in turn, is delivered via a specially shielded coax cable directly to the thruster injector. The location of the generator and the application of shielding mitigates the radiation of emissions outside of the injector. The emission frequency generated by the RF Power Module ("RPM") is controlled and can be adjusted over the frequency range 10.25 to 10.60 GHz as needed. The frequency generator uses a crystal-controlled reference oscillator with a frequency accuracy of 0.28 parts per million, and the synthesizer employed is adjustable over the frequency range, with a resolution of better than 1 kHz. Prior measurements have confirmed that emissions radiating outside of the injector cavity are 100 dB below the maximum generated power output of the RPM. EMI emission levels from the flight thruster payload have been measured in an anechoic facility to ensure that radiated levels do not exceed an RF power level of greater than -50 dBm within the vicinity of the MET (measured at 1 meter from the propulsion system) and that all emissions are contained within a bandwidth of no more than 5 MHz.

Momentus' proposed thruster operations will not cause harmful radiofrequency interfere to incumbent services. The frequency range 10.25 to 10.60 GHz is used on a primary basis by Radiolocation, Fixed, and Mobile services and is used on a secondary basis by the Amateur and Amateur-Satellite radio services in all three International Telecommunication Union ("ITU") regions.[13] The power flux density at the Earth's surface from 300 km, the estimated closest operational distance to the satellite, is far below the PFD threshold specified in the ITU Radio Regulations.[14] At the calculated emission levels, no emissions will be detectable (by a very large

[13] *See* 47 C.F.R. § 2.106.
[14] *See* ITU Radio Regulations 21.16.

margin) by radar, mobile, fixed, or amateur systems. All other emissions from the thruster (*e.g.*, harmonics and sub-harmonics) will be further attenuated by at least an additional 20 dB.[15]

III. Waiver Requests

The Commission may waive any of its rules if there is "good cause" to do so.[16] In general, waiver is appropriate if (1) special circumstances warrant a deviation from the general rule; and (2) such deviation would better serve the public interest than would strict adherence to the rule.[17] Generally, the Commission will grant a waiver of its rules in a particular case if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.[18] Here, the development of efficient, flexible and non-toxic space transportation infrastructure, and the benefits such a service provide – including, critically, the potential to assist in orbital debris risk mitigation – represent a special circumstance warranting waiver of the FCC rules.

A. U.S. Table of Frequency Allocations

1. 2025-2110 MHz TT&C Uplink

This band is allocated to Space Operations and Earth-Exploration Satellites Services ("EESS"), *inter alia*, in all ITU regions. In the United States, Space Operations are limited to federal operators, and EESS use by commercial operators is subject to conditions as may be applied on a case-by-case basis and the limitation that any use may not cause harmful

---

[15] Due to the operation of the equipment as part of the spacecraft, Momentus believes the VR-1 thruster should not be characterized as Industrial, Scientific or Medical equipment. *See* 47 C.F.R. §18.101, *et. seq.* In any event, as discussed above, due to the low calculated emissions levels, the frequency range within which the thruster will operate, and the operations of the equipment in space, the emissions from the propulsion system are unlikely to cause harmful interference to any authorized services.

[16] *See* 47 C.F.R. § 1.3; *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164 (D.C. Cir. 1990); *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).

[17] *See Northeast Cellular*, 897 F.2d at 1166.

[18] *See WAIT Radio*, 418 F.2d at 1157.

interference to authorized operations.[19] As discussed above, Momentus plans to use a ground station in Italy, operated by Leaf Space, to communicate with VR-1 for the provision of in-space transportation services. Accordingly, to the extent necessary, Momentus requests waiver of the Table of Allocations to use the 2025-2110 MHz band (Earth-to-space) for TT&C. Given the limited use of the frequencies during the brief 180-day mission, Momentus' commitment to coordinate use of these frequencies, and the public interest justification supporting the mission, Momentus submits that waiver is warranted.

2. 400.15-401 MHz TT&C Downlink

The 400.15-401 MHz band is allocated for Space Operations (space-to-Earth) on a secondary basis in all ITU regions. As discussed above, Momentus will use these frequencies primarily for TT&C.[20] Given the limited use of the frequencies during the brief 180-day mission, Momentus' commitment to coordinate use of these frequencies, and the public interest justification supporting the mission, Momentus submits that waiver is warranted.

Momentus is aware that the FCC established an October 15, 2019 cut-off deadline for requests to operate, *inter alia*, in the 400.15-401 MHz band for the provision of Mobile-Satellite Service.[21] Momentus proposes to use this band for Space Operations on a secondary basis, consistent with the U.S. Table of Frequency Allocations, and its brief and limited use of the band for TT&C is not mutually exclusive with other operations on a long-term basis. Accordingly, the request to use these frequencies should be considered outside of the 400.15-401 MHz processing round.

---

[19] *See* 47 C.F.R. § 2.106 n. US347.

[20] Such use will also include transmission of limited imagery of the Payloads during deployment primarily to ensure mission safety and success.

[21] *See Cut-off Established for Additional NVNG MSS Applications or Petitions for Operations in the 399.9-400.05 MHz and 400.15-401 MHz Bands*, Public Notice, DA 19-779 (rel. Aug. 15, 2019).

B. 47 C.F.R. § 25.113(g)

The Commission's rules require orbital deployment approval and operating authority to be applied for and granted prior to orbital deployment and operation of a space station. In this case, given (1) the short operational life of the VR-1 spacecraft; (2) the similarity in function of VR-1 to an upper stage launch vehicle; (3) the information contained in this application regarding spacecraft operations and debris mitigation plans; and (4) the public interest justification supporting the mission, Momentus believes the underlying purposes of the rule (to provide sufficient information for the FCC to evaluate the satellite mission) is met and that grant of the requested waiver is justified.[22] Further, the FCC has granted similar applications for in-space transportation spacecraft in the recent past.[23]

IV. ITU Compliance

Momentus has prepared the ITU Advance Publication Information submission for its proposed system and is contemporaneously providing this information to the FCC under separate cover. Attached as an exhibit to this application is a signed ITU cost recovery letter.

Respectfully submitted,

/s/ Philip Hover-Smoot

Philip Hover-Smoot
Chief Ethics & Compliance Officer
Momentus Inc.
3050 Kenneth Street
Santa Clara, CA 95054
+1-650-564-7820

Dated: June 8, 2020

---

[22] Consistent with FCC precedent, *see infra* note 23, Momentus believes that submission of the Schedule S form is not necessary for processing of this application for special temporary authority. But, the company will submit that information if requested to do so by the FCC.

[23] *See* Application of Spaceflight, IBFS File No. SAT-SAT-20180523-00042 (granted Oct. 12, 2018); Application of Spaceflight, IBFS File No. SAT-SAT-20150821-00060 (granted Oct. 26, 2016).

EXHIBIT 1

ITU Cost Recovery Letter

DECLARATION

I, Philip Hover-Smoot, hereby declare the following:

Momentus Inc. ("Momentus") is aware that as a result of actions taken at the International Telecommunication Union's 1998 Plenipotentiary Conference, and further modified by the ITU Council in subsequent years, processing fees will now be charged by the ITU for satellite network filings. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU. Momentus hereby states that it is aware of this requirement and unconditionally accepts all cost recovery responsibilities associated with the ITU filings for the Vigoride-1 or VR-1 satellite network. Please address all correspondence related to the Vigoride-1 satellite network to the following point of contact:

Point of Contact Name: Philip Hover-Smoot

Organization Name: Momentus Inc.

Address: 3050 Kenneth Street
Santa Clara, CA 95054

E-Mail: philip.hover-smoot@momentus.space

Telephone Number: +1-415-254-1295

Sincerely,

/s/ Philip Hover-Smoot

Philip Hover-Smoot
Chief Ethics & Compliance Officer
Momentus Inc.

June 8, 2020