Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Application of	)	
SPACE EXPLORATION HOLDINGS, LLC	)	Call Sign:
For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System Supplement	)	File No. _____

APPLICATION FOR APPROVAL FOR ORBITAL DEPLOYMENT AND OPERATING AUTHORITY FOR THE SPACEX NGSO SATELLITE SYSTEM SUPPLEMENT

William M. Wiltshire
Paul Caritj

HARRIS, WILTSHIRE & GRANNIS LLP
1919 M Street, N.W.
Suite 800
Washington, DC 20036
202-730-1300 tel
202-730-1301 fax

Counsel to SpaceX

Tim Hughes
Senior Vice President, Global Business and Government Affairs

Patricia Cooper
Vice President, Satellite Government Affairs

SPACE EXPLORATION TECHNOLOGIES CORP.
1030 15th Street, N.W.
Suite 220E
Washington, DC 20005
202-649-2700 tel
202-649-2701 fax

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Space Exploration Holdings, LLC, a wholly owned subsidiary of Space Exploration Technologies Corp. (collectively, "SpaceX"), requests operating authority (that is, approval for orbital deployment and a station license) for a non-geostationary orbit ("NGSO") satellite system in the Fixed-Satellite Service ("FSS") operating in Ku- and Ka-band frequencies that supplement those previously proposed for use by SpaceX.[1] A completed Form 312, accompanying Schedule S, Technical Attachment, and Waiver Request are associated with this application, consistent with the information required by the Commission's rules in support of the requested authorization.

[1] *See* IBFS File No. SAT-LOA-20161115-00118 ("Original Application"). Although this application might more appropriately have been styled as an amendment to the system originally proposed, doing so could have resulted in the Original Application being removed from the initial processing round. *See* 47 C.F.R. § 25.116 (providing that a request for a change in frequencies after the cut-off date for an NGSO processing round constitutes a major amendment which will render the original application "newly filed"). Accordingly, much of the content of the Original Application has been repeated herein.

SpaceX seeks authority to use the12.75-13.25 GHz, 19.7-20.2 GHz, and 29.3-29.5 GHz bands, for which one or more other NGSO system application has previously been filed.[2] By augmenting the spectrum available for use, the requested authorization will enhance the NGSO system SpaceX previously proposed and enable it to provide a broader range of services with enhanced operational flexibility. This supplemental spectrum will increase system capacity, and thereby enable SpaceX to both serve more customers and provide them with a higher quality of service.

Utilizing the same number of satellites as originally proposed (4,425), this enhancement would create additional spectrum diversity by expanding the range of both Ku-band spectrum available for user links and Ka-band spectrum available for gateway links. As before, the system would operate in 83 orbital planes (at altitudes ranging from 1,110 km to 1,325 km), along with associated ground control facilities, gateway earth stations, and end user earth stations.[3] When combined with the prior proposal into a single, coordinated system (the "SpaceX System"), this constellation would provide both diverse geographic coverage and the capacity to support a wide range of broadband and communications services for residential, commercial, institutional, governmental and professional users in the United States and globally, including in remote and rural locations currently unserved by other providers.

The same advanced beam-forming and digital processing technologies within the satellites previously proposed in the Original Application will ensure that the entire system makes highly efficient use of spectrum resources and has the flexibility to share that spectrum

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[2] *See* Public Notice, "Applications Accepted for Filing; Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 12.75-13.25 GHz, 13.85-14.0 GHz, 18.6-18.8 GHz, 19.3- 20.2 GHz, and 29.1-29.5 GHz Bands," 32 FCC Rcd. 4180, 4183 (IB 2017).

[3] To the extent necessary, SpaceX hereby incorporates by reference relevant portions of the Original Application.

with other licensed satellite and terrestrial users. Likewise, gateway earth stations will apply advanced phased array technologies to generate high-gain steered beams to communicate with multiple NGSO satellites from a single gateway site. User terminals operating with the SpaceX System will use similar phased array technologies to allow for highly directive, steered antenna beams that track the system's satellites. The system will employ optical inter-satellite links for seamless network management on-orbit and continuity of service, while also aiding compliance with emission constraints designed to facilitate spectrum sharing with other space-based and terrestrial systems.

As with its original proposal, SpaceX anticipates that the first 800 LEO satellites deployed will enable the system to provide initial U.S. and international coverage for broadband services. Deployment of the remainder of that constellation will complete coverage and add capacity around the world. Once fully optimized through deployment of all satellites, the system would be able to provide high bandwidth, low latency broadband services globally.

Consistent with the principles of good spectrum stewardship, the SpaceX System has been designed to maximize the efficient use of spectrum and to ensure protection of other satellite and terrestrial systems by mitigating harmful interference to such systems. The system will be designed for high degrees of adaptability, making it more flexible to accommodate evolutions in broadband service demand and better able to coordinate with existing and future space and terrestrial systems. SpaceX is also committed to meeting or exceeding best practices and international norms to ensure the safety of space. Here, SpaceX will employ advanced space-situational awareness techniques and other methods to mitigate the potential creation of additional orbital debris. To this end, SpaceX will implement an operations plan for the orderly de-orbit of satellites nearing the end of their useful lives (roughly five to seven years) at a rate far

faster than is required under international standards. Satellites will de-orbit by propulsively moving to a disposal orbit from which they will reenter the Earth's atmosphere within approximately one year after completion of their mission.

I. INTRODUCTION AND BACKGROUND

A. SpaceX Background

SpaceX is a private company founded in 2002 by Chief Executive Officer and Lead Designer Elon Musk to revolutionize space technologies, with the ultimate goal of enabling humanity to become a multi-planetary species. The company designs, manufactures, and launches advanced rockets and spacecraft. It has approximately 5,000 employees based in the United States at the company's headquarters in Hawthorne, California; launch facilities at Cape Canaveral Air Force Station and Kennedy Space Center, Florida, and Vandenberg Air Force Base, California; a private launch facility under construction in Brownsville, Texas; and offices in the Washington, D.C. and Seattle, Washington areas. Since its founding, SpaceX has achieved a series of historic milestones, including the launch and reuse of both a spacecraft (Dragon) and several rocket boosters from low-Earth orbit.

SpaceX's current and planned space-based activities illustrate and underscore its commitment to space safety. The company is highly experienced with space-based operations and debris mitigation practices. SpaceX maintains deep ties with the domestic and international institutions tasked with ensuring the continued safety of space operations, which facilitates aggressive and effective space-debris mitigation practices. SpaceX brings this commitment and experience to all aspects of its space-based operations.

B. The SpaceX System

As described in the Original Application, the SpaceX NGSO system consists of a constellation of low-Earth orbit satellites and ground-based technologies. The system is highly spectrum-efficient, sharing both Ku- and Ka-band spectrum with conventional geostationary orbit ("GSO") satellite and terrestrial networks without causing harmful interference. It will operate under network filings made on behalf of SpaceX at the International Telecommunication Union ("ITU") by both the United States and Norway.

SpaceX has designed its system to achieve the following objectives:

- High capacity: The SpaceX System will be able to provide high volume broadband capacity over a wide area. SpaceX will periodically improve the satellites over the course of the multi-year deployment of the system, which may further increase capacity.

- High adaptability: The system leverages phased array technology to dynamically steer a large pool of narrow beams to focus capacity where it is needed. Optical inter-satellite links permit flexible routing of traffic on-orbit. Further, the constellation ensures that a variety of frequencies can be reused effectively across different satellites operating at different altitudes and in different planes to enhance the flexibility, capacity, and robustness of the overall system.

- Expansive coverage: With deployment of the first 800 satellites of the LEO Constellation, the system will be able to provide initial U.S. and international broadband connectivity; when fully deployed, the system will add capacity and availability at the equator and poles.

- Efficiency: SpaceX is designing the overall system from the ground up with cost-effectiveness and reliability in mind, from the design and manufacturing of the space and ground-based elements, to the launch and deployment of the system using SpaceX launch services, development of the user terminals, and end-user subscription rates.

The various space and ground facilities composing the SpaceX System are described below and in more detail in Schedule S and the Technical Attachment (Attachment A) accompanying this application.

1. Space Segment

The SpaceX System will consist of 4,425 satellites operating in 83 orbital planes. The overall constellation will be configured as follows:

SPACEX SYSTEM CONSTELLATION					
Parameter	**Initial Deployment (1,600 satellites)**	**Final Deployment (2,825 satellites)**			
Orbital Planes	32	32	8	5	6
Satellites per Plane	50	50	50	75	75
Altitude	1,150 km	1,110 km	1,130 km	1,275 km	1,325 km
Inclination	53º	53.8º	74º	81º	70º

This constellation will enable SpaceX to provide full and continuous coverage of the Earth utilizing a minimum elevation angle of 40 degrees.

SpaceX anticipates that the first 800 satellites of the Initial Deployment (32 planes with an initial 25 satellites per plane) will enable the system to provide initial U.S. and international coverage sufficient to offer commercial broadband service. Completion of the 53º inclination orbit will add capacity throughout the system and provide robust broadband connectivity around the globe, with service concentrated in the area between 60 degrees North Latitude and 60 degrees South Latitude. Launch of the final 2,825 satellites will complete this aspect of the overall system, further increasing available capacity and extending geographic coverage to polar and high-latitude regions above 60 degrees North Latitude and below 60 degrees South Latitude. As each satellite is launched and brought into operation, it will be immediately integrated into the system and used to enhance broadband service offerings.

The SpaceX System will use Ka-band spectrum for communications between satellites and gateways, and Ku-band spectrum for communications between satellites and user terminals.[4] The table below shows all Ku- and Ka-band spectrum used by the SpaceX System, with the supplemental frequencies requested in this application highlighted in bold:

Type of Link and Transmission Direction	**Frequency Ranges**
User Downlink Satellite-to-User Terminal	10.7 – 12.7 GHz
Gateway Downlink Satellite to Gateway	17.8 – 18.6 GHz 18.8 – 19.3 GHz **19.7 – 20.2 GHz**
User Uplink User Terminal to Satellite	**12.75 – 13.25 GHz**[5] 14.0 – 14.5 GHz
Gateway Uplink Gateway to Satellite	27.5 – 29.1 GHz **29.3 – 29.5 GHz** 29.5 – 30.0 GHz
TT&C Downlink	12.15 – 12.25 GHz 18.55 – 18.60 GHz
TT&C Uplink	13.85 – 14.00 GHz

[4] In the future, SpaceX may seek authority to use certain Ka-band spectrum for communications to and from user terminals as well. The system will also employ optical inter-satellite links for communications directly between SpaceX satellites. As the Commission has previously found, "[b]ecause optical ISLs do not involve wire or radio frequency transmissions, the Commission does not have jurisdiction over the use of optical ISLs." *Teledesic LLC*, 14 FCC Rcd. 2261, ¶ 14 (Int'l Bur. 1999). Moreover, to the extent that the use of optical ISLs alleviates congestion in radio frequency bands, it is to be encouraged. *Id.* SpaceX has provided additional information with respect to its optical ISLs, which is incorporated herein by reference. *See* Letter from William M. Wiltshire to Jose P. Albuquerque, IBFS File No. SAT-LOA-20161115-00118, at 12-15 (Apr. 20, 2017).

[5] At this time, SpaceX seeks authority to use this band in the United States only with individually-licensed earth stations. No such limitations would apply outside the U.S. In the future, SpaceX may seek authority to operate blanket-licensed user terminals in the U.S. as well.

A more precise description of the frequency and channelization plan for the SpaceX System is included in Schedule S and the Technical Attachment accompanying this application.

2. Ground Segment

The SpaceX System includes three broad categories of earth stations: tracking, telemetry and control ("TT&C") stations; gateway earth stations; and user terminals.[6] The Ka-band gateway earth stations will use phased array antenna technology, with several hundred locations anticipated within the U.S., co-located with or sited near major Internet peering points to provide the required Internet connectivity to the satellite constellation. The Ku-band user terminals will also communicate using phased array antenna technology, and be designed for efficiency, cost, and ease of installation.

SpaceX will submit applications to the Commission requesting individual licenses for any TT&C stations and gateway earth stations, and a blanket license for user terminals to be located in the United States, pursuant to Sections 25.115 and 25.130 of the Commission's rules.[7]

II. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

Worldwide demand for broadband services and Internet connectivity continues to evolve, with escalating requirements for speed, capacity, and reliability. The volume of traffic flowing over the world's networks has exploded, with one report estimating that annual global Internet protocol ("IP") traffic reached 1.2 zettabytes in 2016 – meaning that approximately

[6] Because SpaceX will conduct TT&C activities in spectrum sought under the Original Application, it is not discussed here.

[7] *See* 47 C.F.R. §§ 25.115, 25.130.

1,200 billion gigabytes of data were exchanged worldwide last year.[8] By 2021, that figure is projected to nearly triple (reaching a level more than 125 times greater than the global IP traffic in 2005), global fixed broadband speeds will nearly double, and the number of devices connected to IP networks will be more than three times as high as the global population.[9]

Diverse technology platforms currently serve this booming broadband demand, from terrestrial fiber and cable systems to mobile cellular networks and space-based systems, and innovative new alternatives continue to be proposed to meet the world's broadband demand. Yet many parts of the United States and the world lack access to reliable broadband connectivity. The Commission continues to conclude that advanced telecommunications capability is not being deployed to all Americans in a reasonable and timely fashion.

> Despite the increase in the number of Americans that are able to obtain advanced telecommunications capability, these advances are not occurring broadly enough or quickly enough to achieve our statutory objective. Nationwide, one in ten Americans lacks access to 25 Mbps/3 Mbps broadband. As importantly, there continues to be a significant disparity of access to advanced telecommunications capability across America with more than 39 percent of Americans living in rural areas lacking access to advanced telecommunications capability, as compared to 4 percent of Americans living in urban areas, and approximately 41 percent of Americans living on Tribal lands lacking access to advanced telecommunications capability. We note that small businesses tend to subscribe to mass market broadband service. Thus, the rural-urban disparity in deployment of these broadband services also disproportionately impacts the ability of small businesses operating in rural areas to successfully compete in the 21st century economy.[10]

Internationally, the disparities between broadband access and absence are even greater. As the

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8 *See* Cisco Visual Networking Index: Forecast and Methodology, 2016-2021, at 1 (June 6, 2017), *available at* http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360 html.

9 *Id.*

10 *See Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act*, 31 FCC Rcd. 699, ¶ 4 (2016).

U.N. Broadband Commission for Sustainable Development recently noted,

> Today, 4.2 billion people (or 57% of the world's population) are offline for a wide range of reasons, but often also because the necessary connectivity is not present or not affordable. Information and Communication Technologies (ICTs) are vital enablers of the three pillars of sustainable development – economic development, social development and environmental protection. . . . In developing countries, broadband can help meet the basic needs of food, water and energy, as well as access to health services and education.[11]

On his very first day in office, Chairman Pai noted the importance of this issue and made addressing it a priority.

> One of the most significant things that I've seen during my time here is that there is a digital divide in this country – between those who can use from cutting-edge communications services and those who do not. I believe one of our core priorities going forward should be to close that divide – to do what's necessary to help the private sector build networks, send signals, and distribute information to American consumers, regardless of race, gender, religion, sexual orientation, or anything else. We must work to bring the benefits of the digital age to all Americans.[12]

This has practical, economic, and social implications. Those who do not have access to high-quality broadband service face a distinct disadvantage and are denied the opportunities that other Americans in areas with rich broadband assets take for granted.

Satellite technology has long helped to alleviate the inequities in availability of communications services, in part due to its geographic reach. Historically, satellites first revolutionized the availability of international telephony, then pioneered global distribution of

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[11] Broadband Commission for Sustainable Development, "Open Statement from the Broadband Commission for Sustainable Development to the UN High-Level Political Forum (HLPF)" (July 11, 2016), *available at* http://broadbandcommission.org/Documents/publications/HLPF-July2016.pdf. *See also* Broadband Commission for Sustainable Development, "The State of Broadband 2015," at 8 (Sep. 2015), *available at* http://www.broadbandcommission.org/Documents/reports/bb-annualreport2015.pdf ("A large body of evidence has now been amassed that affordable and effective broadband connectivity is a vital enabler of economic growth, social inclusion and environmental protection." (footnotes omitted)).

[12] Remarks of Ajit Pai, Chairman, Federal Communications Commission, at 2 (Jan. 24, 2017), *available at* http://transition fcc.gov/Daily_Releases/Daily_Business/2017/db0124/DOC-343184A1.pdf.

video content. More recently, satellite systems have introduced broadband connectivity for mobile platforms, such as aircraft and ships.

The SpaceX System will bring new broadband capability to the U.S. and international markets by applying cutting-edge space technologies and spectrum re-use approaches and leveraging its space-based design, manufacturing, and launch experience. Technologies such as dynamic beam forming and phased array antennas both in space and on the ground, optical inter-satellite links, and more powerful computing and software capabilities will enable SpaceX to allocate broadband resources in real time, so that capacity can be placed where it is most needed and energy can be directed away from areas where it might cause interference to other systems. This ability to modify service as necessary is critical to meet rapidly changing customer demands and responsibly utilize spectrum. In addition, the SpaceX broadband service will have similar latency to terrestrial alternatives, enabling the SpaceX NGSO system to support real-time conferencing, telemedicine, gaming, and other latency-sensitive Internet services.

SpaceX proposes to launch and operate an NGSO FSS constellation of 4,425 satellites. While the number of spacecraft may seem large, SpaceX has carefully designed the constellation to fulfill its primary service objective of providing high-speed broadband directly to end users and to achieve two important technical goals: maximum spectrum efficiency within its system, and enhanced spectrum sharing capability with other licensed systems. At the same time, SpaceX has also considered fully the operational and functional parameters of the constellation to ensure that it can achieve these goals while operating in a responsible way to safeguard space for all those who want to operate there.

SpaceX has designed its system to use a large number of satellites, each with a large number of narrow beams, reusing frequencies many times over to generate a level of capacity that can meaningfully bridge the broadband connectivity gap experienced by many end-users in the U.S. and around the world. NGSO systems with numerous small spot beams that reuse frequencies many times over will achieve greater spectral efficiency – *i.e.*, more megabits per second, per square kilometer, per MHz for broadband use – and greater overall system capacity within the same amount of spectrum.

The SpaceX System was also designed to ensure protection of existing satellite and terrestrial systems from harmful interference and maximize its efficient use of spectrum. As demonstrated in the Technical Attachment, Waiver Requests, and Schedule S accompanying this application, the system will not create harmful interference to other satellite and terrestrial systems. SpaceX is committed to facilitating co-frequency sharing with terrestrial and GSO systems. In addition, SpaceX has designed its system to enable it to share limited Ku- and Ka-band spectrum resources with other proposed and operational NGSO systems. The ability to share available spectrum in an efficient manner among NGSO systems will be a prerequisite to optimizing broadband speeds and increasing broadband availability for customers in the U.S. and around the world. SpaceX will seek in every case to reach coordination agreements that optimize spectrum efficiency and allow for the greatest operational flexibility possible among the systems, consistent with the Commission's rules and policies.[13]

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[13] *See, e.g.*, 47 C.F.R. § 25.261 (procedures for avoidance of in-line interference for Ka-band NGSO systems); *Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, 17 FCC Rcd. 7841, ¶¶ 27-32 (2002) (discussing the means for intra-service sharing among prospective NGSO FSS licensees in the Ku-band); *Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band*, 18 FCC Rcd. 14708, ¶¶ 18-21 (2003) (discussing the means for sharing among existing and prospective NGSO FSS licensees in the Ka-band).

By designing a satellite constellation that can scale to high levels of capacity by achieving efficient and equitable spectrum usage that will also preserve a safe operating environment in space, SpaceX has created a space-based platform that can deliver the next generation of broadband services. This will enable SpaceX to play an important role in closing the digital divide and giving everyone – including those underserved or unserved by existing alternatives – the opportunity to participate more fully in the nation's economic and civic life.

A. Eligibility and Operational Requirements

To the extent necessary, SpaceX confirms that (1) it has no right that would run afoul of the prohibition in Section 25.145(e) of the Commission's rules,[14] nor will it acquire any such right in the future; (2) it will post a surety bond as required under Section 25.165 of the Commission's rules;[15] (3) it will comply with the Commission's milestone requirements, subject to its request for a limited waiver;[16] and (4) it does not have any other application for an NGSO-like satellite system license on file with the Commission, or any licensed-but-unbuilt NGSO-like system, in any frequency band involved in this application.[17]

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[14] *See* 47 C.F.R. § 25.145(e) ("No license shall be granted to any applicant for a space station in the FSS operating in portions of the 18.3-20.2 GHz and 28.35-30.0 GHz bands or any persons or companies controlling or controlled by the applicant, shall acquire or enjoy any right, for the purpose of handling traffic to or from the United States, its territories or possessions, to construct or operate space segment or earth stations, or to interchange traffic, which is denied to any other United States company by reason of any concession, contract, understanding, or working arrangement to which the Licensee or any persons or companies controlling or controlled by the Licensee are parties.").

[15] *See id.* § 25.165(a)(1).

[16] *See id.* § 25.164(b). In its Waiver Request, SpaceX seeks relief from the implementation milestone in recognition of the practical challenge of launching and beginning operations of over 4,400 satellites within six years of licensing and the operational capability to initiate commercial broadband service provision upon the launch of an initial 800 satellites.

[17] *See id.* § 25.159(b).

III. ITU COST RECOVERY

SpaceX 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. SpaceX 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.

IV. CONCLUSION

For the foregoing reasons, and for the reasons set forth in the accompanying materials and the Original Application, SpaceX requests that the Commission find that granting approval for orbital deployment and a station license (*i.e.*, operating authority) for the SpaceX System using this supplemental spectrum would serve the public interest, and issue such grant expeditiously.

Respectfully submitted,

SPACE EXPLORATION HOLDINGS, LLC

By: */s/ Tim Hughes*
Tim Hughes
Senior Vice President, Global Business and Government Affairs

Patricia Cooper
Vice President of Satellite Government Affairs

SPACE EXPLORATION TECHNOLOGIES CORP.
1030 15th Street, NW
Suite 220E
Washington, DC 20005
202-649-2700 tel
202-649-2701 fax

William M. Wiltshire
Paul Caritj
HARRIS, WILTSHIRE & GRANNIS LLP
1919 M Street, N.W.
Suite 800
Washington, DC 20036
202-730-1300 tel
202-730-1301 fax

Counsel to SpaceX