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	)	File No. _____

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

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November 15, 2016

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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"). This system (the "SpaceX System") will operate using Ku- and Ka-band frequencies. 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. Grant of this application will enable SpaceX to bring high-speed, reliable, and affordable broadband service to consumers in the U.S. and around the world, including areas underserved or currently unserved by existing networks.

SpaceX plans to deploy a constellation of low-Earth orbiting satellites featuring highly-intelligent and adaptive spacecraft, as well as best-in-class technology for ground operations. The SpaceX System consists of 4,425 satellites operating in 83 orbital planes (at altitudes

ranging from 1,110 km to 1,325 km), as well as associated ground control facilities, gateway earth stations and end user earth stations. The system is designed to provide a wide range of broadband and communications services for residential, commercial, institutional, governmental and professional users worldwide. Advanced beam-forming and digital processing technologies within the satellite payload give the system the ability to make highly efficient use of Ku- and Ka-band spectrum resources and the flexibility to share that spectrum with other licensed satellite and terrestrial users. Gateway earth stations also 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 low-Earth orbit satellites. The system will also employ optical inter-satellite links for seamless network management and continuity of service, which will also aid in complying with emissions constraints designed to facilitate spectrum sharing with other systems

An Initial Deployment of 1,600 satellites will operate at a single orbital altitude, with a Final Deployment of 2,825 satellites operating at four additional altitudes for a total of 4,425 operational satellites. With deployment of the first 800 satellites, SpaceX will be able to provide widespread U.S. and international coverage for broadband services. Once fully optimized through the Final Deployment, the system will be able to provide high bandwidth (up to 1 Gbps per user), low latency broadband services for consumers and businesses in the U.S. and globally. Subject to additional development work, SpaceX plans to design and manufacture its own satellites, gateway earth stations, and user terminals.

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. 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. Here, SpaceX will also employ advanced space-situational awareness techniques and other methods to mitigate the potential creation of additional orbital debris.

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.

SpaceX is well-known as the world's fastest-growing provider of commercial space launch transportation services. Since its founding in 2002, SpaceX has achieved a series of historic milestones. In December 2010, SpaceX became the first private company ever to

successfully launch and return a spacecraft (Dragon) from low-Earth orbit. In May 2012, the company again made history when Dragon berthed with the International Space Station ("ISS"), delivered cargo, and returned safely to Earth – a technically challenging feat previously accomplished only by governments. In December 2015, SpaceX successfully returned a first stage rocket booster to land after carrying a payload to space, and has since landed five additional times (four of them on a droneship at sea). SpaceX plans to reuse the first of these flight-proven boosters for an upcoming launch of a commercial satellite.

SpaceX's current and planned space-based activities 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

The SpaceX System consists of a constellation of low-Earth orbit satellites and ground-based technologies, which will include inexpensive and lightweight user terminals. 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: Each satellite in the SpaceX System provides aggregate downlink capacity to users ranging from 17 to 23 Gbps, depending on the gain of the user terminal involved. Assuming an average of 20 Gbps, the 1600 satellites in the Initial Deployment would have a total aggregate capacity of 32 Tbps. 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 beams to focus capacity where it is needed. Optical inter-satellite links permit flexible routing of traffic on-orbit. Further, the constellation ensures that frequencies can be reused effectively across different satellites to enhance the flexibility and capacity and robustness of the overall system.

- Broadband services: The system will be able to provide broadband service at speeds of up to 1 Gbps per end user. The system's use of low-Earth orbits will allow it to target latencies of approximately 25-35 ms.

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

- Low cost: 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.

- Ease of use: SpaceX's phased-array user antenna design will allow for a low-profile user terminal that is easy to mount and operate on walls or roofs.

The various space and ground facilities comprising 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 will be able to provide early beta-coverage at certain high latitudes with as few as 100 satellites (using 4 of the 32 planes in the Initial Deployment). The system will achieve widespread U.S. and international coverage for commercial broadband service offerings with the deployment of the first 800 satellites of the Initial Deployment (32 planes with initial 25 satellites per plane). Completion of the Initial Deployment will add capacity throughout the system and increase coverage at equatorial latitudes. 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 1,600 satellites in the Initial Deployment will 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 remaining 2,825 satellites in the Final Deployment will complete the overall constellation, further increasing system capacity and extending coverage to polar and high-latitude regions.

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.[1] SpaceX requests authority to operate on the following frequencies:

[1] 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.*

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
User Uplink User Terminal to Satellite	14.0 – 14.5 GHz
Gateway Uplink Gateway to Satellite	27.5 – 29.1 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

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. The TT&C stations will be on the order of five meters in diameter, and relatively few in number (*e.g.*, primary and back-up TT&C locations in the United States, with several more locations distributed internationally). 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.[2]

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 continues to explode, with one estimate projecting that annual global Internet protocol ("IP") traffic will surpass the zettabyte threshold in 2016 – meaning that over 1,000 billion gigabytes of data will be exchanged worldwide this year.[3] By 2020, that figure is projected to more than double (reaching a level nearly 100 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 three times as high as the global population.[4]

Diverse technology platforms currently serve this booming broadband demand, from terrestrial fiber and cable systems to mobile cellular networks and space-based systems, and

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2 *See* 47 C.F.R. §§ 25.115, 25.130.

3 *See* Cisco Visual Networking Index: Forecast and Methodology, 2015-2020, at 1 (June 6, 2016), *available at* http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf.

4 *Id.* at 1-2.

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, even in 2016, 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.[5]

Internationally, the disparities between broadband access and absence are even greater. As the 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.[6]

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[5] *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).

[6] 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

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 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.

The SpaceX System was 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. Recognizing the potential of NGSO FSS systems, the 2000 World Radiocommunication Conference ("WRC") adopted technical sharing criteria designed to enable such systems to share spectrum with incumbent services without causing unacceptable interference to them.

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has now been amassed that affordable and effective broadband connectivity is a vital enabler of economic growth, social inclusion and environmental protection." (footnotes omitted)).

That regime included technical criteria for sharing both Ku- and Ka-band spectrum among NGSO FSS and terrestrial fixed systems (which focused on power flux-density ("PFD") limits on downlink transmissions) and among NGSO FSS and GSO FSS operations (which focused on single-entry equivalent power flux-density ("EPFD") limits on uplink and downlink transmissions).[7] The Commission has officially codified much of that regime into its own rules.[8]

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.[9]

A. Eligibility and Operational Requirements

To the extent necessary, SpaceX confirms that (1) it has no right that would run afoul of

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7 *See generally* ITU Radio Regs., Articles 21 and 22.

8 *See, e.g.*, 47 C.F.R. § 25.208; *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-band Frequency Range*, 16 FCC Rcd. 4096 (2000).

9 *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).

the prohibition in Section 25.145(e) of the Commission's rules,[10] 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;[11] (3) it will comply with the Commission's milestone requirements, subject to its request for a limited waiver;[12] 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.[13]

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

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[10] *See* 47 C.F.R. § 25.145(e) ("No license shall be granted to any applicant for a space station in the Fixed-Satellite Service operating in the 20/30 GHz band if that applicant, or any persons or companies controlling or controlled by the applicant, shall acquire or enjoy any right, for purposes of handling traffic to or from the United State, its territories or possession, 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.").

[11] *See id.* § 25.165(a)(1).

[12] *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.

[13] *See id.* § 25.159(b).

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

Respectfully submitted,

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