SPACEX

September 21, 2020

The Secretary
Telecommunications Regulatory Authority of India (TRAI)
New Delhi
Submitted Via Email to: jams@trai.gov.in and sksinghal@trai.gov.in

RE: TRAI Consultation Paper on Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed

Space Exploration Technologies Corp. (SpaceX) appreciates this opportunity to provide input to the Telecommunications Regulatory Authority of India (TRAI) in response to the Consultation Paper on Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed, issued 20 August 2020 (the "Consultation Paper").

SpaceX commends TRAI for its ongoing evaluation of rules, regulations and policies that can foster expanded deployment of and access to quality broadband services for Indian consumers, business, institutions and government. The Government of India has set ambitious and laudable connectivity goals in its Connect India mission. The Consultation Paper accurately notes that "innovative approaches to infrastructure creation need to be devised" to realize these objectives. A diverse mix of broadband technology platforms and service providers, including those new to India's market, will best accelerate broadband access across the nation.

Internet access has quickly become a necessity—and an equalizer—for all people in the world. Individuals, businesses, institutions and governments rely on broadband for any number of services, from remote learning to telework to telehealth, now more than ever. The current COVID-19 pandemic has unequivocally demonstrated that, while existing telecommunications networks have performed well to meet these needs in many areas, billions that live in the most rural and remote areas, and even those in urban environments, remain on the wrong side of the digital divide. Powerful next-generation satellite systems *flying today* that can reach all corners of the country with high-speed, affordable service are critical to bridging this gap.

As a global leader in space manufacturing, launch and operations, India is well aware of the transformational potential that space and satellite technologies add to the communications market. While the Consultation Paper focuses primarily on issues related to fixed broadband, fixed wireless access, and mobile broadband, SpaceX notes that TRAI and other Government of India agencies have acknowledged both the role that satellite services can play and the opportunity to identify and implement actions to encourage the fast deployment of new technologies and consumer telecommunication services.

Indeed, SpaceX's Starlink high-capacity, high-speed, low-latency satellite network will advance the goal of delivering broadband connectivity in the near term to all Indians, particularly those without access now or in the near-term to broadband services traditionally available only to customers in urban and suburban areas.

Notably, new technologies like Starlink may require consideration of updated rules, policies and regulation. Accordingly, SpaceX respectfully recommends that TRAI undertake the following actions to provide consumers with more choices and better service, to include:

- Encouraging technology-neutral broadband definitions that reflect the advances of next-generation satellite services;
- Assigning already-allocated frequencies for use by satellite systems;
- Extending "blanket" licensing tools to support the wide-spread availability of satellite user terminals;
- Promoting maximum spectrum efficiency by expecting users to coordinate use of scarce spectrum resources across multiple systems, whether terrestrial or space-based;
- Safeguarding ongoing satellite innovation in higher frequency bands, while maintaining the expectation that all spectrum users, terrestrial and space-based, will coordinate in good faith; and,
- Considering the unintended fees, taxes and other administrative burdens that, when passed on to end-users, can make broadband unaffordable to many.

A combination of such regulatory actions can foster best of class technology deployment throughout India and maximize the choices available to all Indian consumers.

About SpaceX

SpaceX is a private American company founded in 2002 by Elon Musk to revolutionize space technologies, with the ultimate goal of enabling humanity to become a multi-planetary species. The company and its more than 7,000 employees design, manufacture and launch advanced rockets and spacecraft.

SpaceX has achieved a series of historic milestones, including becoming the first private company to successfully launch and return a spacecraft (Dragon) from low-Earth orbit (LEO) in December 2010. In May 2012, the company again made history when Dragon berthed with the International Space Station (ISS), delivered cargo for the astronauts on board, and returned safely to Earth–a technically challenging feat previously accomplished only by governments. And, in May 2020, SpaceX became the first private company in history to send astronauts to orbit, safely returning them to Earth two months later. To date, SpaceX has successfully launched nearly 100 missions to space.

About Starlink

SpaceX is leveraging its accumulated expertise in space system manufacturing, design and operations to develop Starlink, a constellation of satellites designed to provide high-speed, low-latency, competitively-priced broadband service to locations around the world where access to the Internet has been unreliable, expensive or completely unavailable.

The first Starlink constellation consists of over 4,400 non-geostationary orbit (NGSO) satellites employing advanced communications and space operations technology. To date, SpaceX has launched over 700 Starlink satellites in a little over 16 months, and is now the largest operational satellite constellation by a more than factor of two. Since 2018, SpaceX has invested hundreds of millions of dollars in Starlink and is currently building 120 satellites per month, along with thousands of end-user terminals each month.

SpaceX is already testing Starlink's broadband service in the United States among SpaceX Friends & Family, and then will move quickly to a ~~public beta~~ limited public release followed by a larger U.S. and international rollout. For India, SpaceX is on track with constellation deployments for continuous Starlink coverage throughout India by the end of 2021 with corresponding service capability, regulatory approvals permitting.

SpaceX Comments

Broadband Speed Definitions and Access

In Question 1, TRAI asks whether to review the existing definition of broadband, which envisions fixed line broadband access to 50 percent of households by 2022, universal broadband connectivity at 50 Mbps to every citizen and 100 Mbps broadband on-demand to all key development institutions, along with 1 Gbps connectivity to all Gram Panchayats of India in 2020 and 10 Gbps by 2022.

Starlink's early performance tests demonstrate that NGSO satellite technology is clearly capable of meeting not only the current broadband definition, but also those increased criteria recommended by TRAI. Policies that constrain or deter use of such advanced satellite technology in India's broadband mix may be a contributor to the concern referenced in Question 22 of higher costs of fixed broadband and in Question 26 of the slower speeds of existing fixed broadband services.

Terrestrial fixed wired and wireless technologies have brought economic and social advancement across India, but come with an inherent infrastructure expense based on a cost per kilometer that is difficult to scale while maintaining affordable prices for end users when connecting remote or rural communities. This "last-mile" reality is at the heart of the Consultation Paper's Question 23 and Question 25 on slow adoption of Fiber to the Home (FTTH) and Fixed Wireless (FWA) networks, respectively.

SpaceX does not require expensive "last-mile" fiber lines in order to deliver reliable high-speed broadband. In fact, the "last-mile" for SpaceX's Starlink satellite system consists of the Ku-band connection from the consumer's home directly to a satellite in orbit, entirely eliminating the largest cost inhibitor to near-term universal broadband coverage in India. Customers connect to the Starlink network using a single User Terminal (UT) featuring an advanced phased-array antenna that connects to a Wi-Fi router within a home, a business, school or community center. A Starlink Wi-Fi router can also distribute connectivity outside for shared use. SpaceX is designing the Starlink User Terminal to be easy to install and attainably priced for consumers. Critically, this combined last-mile and middle-mile architecture allows consumers who live hundreds of miles from the nearest fiber access point to still receive high-throughput, low-latency service. A location divide need no longer cause a digital divide.

SpaceX defers to TRAI the assessment of the proper speeds and performance appropriate for the Indian marketplace, but recommends to TRAI a consumer-centered approach that sets rigorous performance standards, regardless of the technology used to deliver the suite of services and applications noted in the Consultation Paper: web browsing, video streaming, digital meeting platforms, tele-health, tele-medicine, virtual learning, e-Commerce, e-Governance, online banking and e-payments. In particular, broadband networks should be capable of the latency necessary to support real-time voice services. As consumers in urban, suburban and even many rural areas move away from standalone voice services, the broadband

definition should ensure that the same internet with the same services and ability to support Voice Over Internet Protocol (VoIP) should be available to all Indian users, whether in areas more economically attractive to serve for traditional fiber networks or more remote or high-cost areas. Indeed, if a technology is capable of meeting the broadband definitions identified, the regulatory and policy structure should enable that technology to enter the broadband mix of connectivity solutions in India.

SpaceX emphasizes to TRAI that the new generation of NGSO satellite systems is more than capable of meeting both the established and proposed broadband metrics. Within the Consultation Paper, TRAI has already recognized the wave of innovation and investment in satellite communication technology and networks, including the development of large NGSO spacecraft constellations. SpaceX stands ready to discuss how innovation in satellite design, deployment and ground networks can support the country's broadband goals.

Starlink's service capabilities are real today, not theoretical. For example, due to its operating orbit and low processing times, SpaceX's Starlink network offers broadband service with latency that is approximately 25 times lower than traditional geostationary orbit (GSO) satellite systems, alongside significantly higher individual user capacity. Hundreds of private beta users across the United States are already using SpaceX's service. While the system's performance is rapidly accelerating in real time as SpaceX deploys additional spacecraft and implements software improvements, the Starlink network has successfully demonstrated its ability to surpass the Commission's Above Baseline and Low Latency performance tiers, including:

- Exceeding 100 Mbps download speeds and 20 Mbps upload speeds
- Latency measurements for round-trip of less than 40-50 ms

Spectrum Availability

In addition to providing an alternative or complementary choice of end-user broadband providers beyond terrestrial fixed and mobile, SpaceX believes in a robust, competitive broadband market driven by innovation and efficiency that maximizes consumer choice. This ideal marketplace requires providers—whether terrestrial or satellite—to privately coordinate spectrum usage. TRAI should implement policies to incent spectrum efficiency and spectrum sharing among broadband providers to deliver the most service to Indian citizens and businesses.

SpaceX agrees with TRAI observations in Section 2.15 that adjustments to national spectrum assignments would enable India to unlock connectivity from new satellite broadband constellations, and commends TRAI for its recommendations on satellite spectrum dated 17th April 2015 on "Delivering Broadband Quickly: What do we need to do?" SpaceX's views on policy approaches for particular radiofrequency bands is laid out below.

While recognizing that such matters may be outside of TRAI's remit, SpaceX supports the adoption of an "open skies" approach, not only for Very Small Aperture Terminals (VSATs), but for the emerging satellite broadband services as well. As is being discussed in many venues, TRAI's recommendation to separate the functions of a licensing agency, regulator and space operator is also a strong signal that the country values broadband connectivity delivered on advanced satellite platforms.

<u>Ku-band Blanket Licensing</u>

SpaceX encourages TRAI to extend the existing licensing regime for multiple identical satellite terminals, often referred to as a "blanket license." Such a "blanket license" would streamline the site-per-site licensing requirements and accelerate widespread deployment of two-way satellite broadband terminals to support innovative satellite services in India, including the broadband Internet service that SpaceX is preparing to deliver. To extend services to currently unserved or underserved areas, the blanket licenses should be permitted for all satellite broadband terminals, not just VSATs.

SpaceX´s Starlink broadband user terminals are intended to be ubiquitous, with a "one terminal per end user" premise. For example, on March 13, 2020 the U.S. Federal Communications Commission (FCC) granted SpaceX a blanket license to deploy up to 1,000,000 end user terminals in the United States, and have applied for approval of yet another 5,000,000. Extending blanket licensing to broadband terminals would expand the number of Indian consumers that can be supported by emerging NGSO satellite constellations, such as Starlink.

Several other jurisdictions that allow blanket licensing of transmitting and receiving earth stations in some or all of the 10.7-12.7 GHz range and transmitting earth stations in the 14.0-14.5 GHz have adopted this approach. Many regulators around the world recognize the benefit of blanket licensing to advance their goals for broadband access and administrative efficiency. Specifically, Australia, Austria, Canada, Chile, France, Germany, Greece, New Zealand, Spain and the United Kingdom, among others, have adopted blanket licensing approaches. In the United States, FCC rules for blanket licensing of user terminals are codified at 47 C.F.R. §25.115(f)(2).

Ka-band Assignment

Many next generation Fixed Satellite Services (FSS) systems, including Starlink, utilize Ka-band frequencies. SpaceX draws TRAI's attention to Ka-band and notes that the Government of India's National Frequency Table has allocated these frequencies for FSS use, in keeping with the recommendations of the International Telecommunications Union (ITU).

Specifically, many NGSO constellations that are planned or are already in deployment rely on the Ka-band for essential up- and down-link communications to the gateway satellite earth stations that aggregate user traffic and connect to the terrestrial-based internet infrastructure. For example, SpaceX's Starlink system is licensed by FCC to use the 27.5 - 29.1 GHz and 29.5 – 30.0 GHz bands for ground to space uplinks from gateway earth stations to Starlink satellites, and 17.8 – 18.6 GHz and 18.8 – 19.3 GHz bands to downlink space to ground. Other proposed NGSO constellations envision use of Ka-band for both gateway communications links as well direct links with end-users.

However, while India has long encouraged satellite operators to deploy gateway earth station facilities within the country, this policy is thwarted by the absence of Ka-band frequency assignments that are required to communicate with those gateway earth stations. SpaceX encourages TRAI and spectrum agencies in India to develop an approval process for these assignments. This effort is fundamental to expanded high-speed broadband service in India.

E- and V-bands

SpaceX appreciates TRAI's efforts to encourage expanded use of the V- and E- band frequency ranges, as noted in Section 2.10 of the Consultation Paper, and encourages TRAI to consider the potential of satellite operations in both bands, in keeping with allocations at the ITU.

As other spectrum bands used traditionally by satellite become more congested, TRAI rightly suggests exploring extremely high-frequency bands for new usage cases, including the possibility of facilitating the provision of wireless broadband for 5G and accommodating the deployment of broadband services to aircraft and ships. Increasing the amount and types of spectrum available to broadband providers of all kinds is an important step in meeting TRAI's goal of closing the digital divide using whatever technologies best suit consumer needs, including 5G. In working towards this goal, however, it is important that TRAI take into account the impact of proposed rules changes on satellite use of the E- and V-bands, and that new uses of the spectrum do not infringe upon planned and future FSS operations.

In the V-band, SpaceX notes a considerable number of systems already filed at the ITU and, in the case of Starlink, already licensed in November 2018 by the U.S. FCC to add the 37.5-42.0 GHz, and 47.2-50.2 GHz frequency bands to its previously authorized Ku-/Ka-band NGSO constellation and add an NGSO constellation consisting of 7,518 satellites using the 37.5-42.0 GHz and 47.2-50.2 frequency bands.

V-band is illustrative of the potential for satellite and terrestrial spectrum sharing. Starlink uses highly directional space station and earth station beams, along with elevation angles and satellite diversity that allow service to any given customer location from many different satellites. In tandem with the relatively short-range horizontally-directional terrestrial applications in the same V-band, the potential for spectrum sharing is promising, particularly with encouragement for good faith coordination. As to the prospect of sharing with other GSO or NGSO systems, it should be noted that ITU has not adopted GSO/NGSO sharing criteria for the V-band, such as the equivalent power flux-density ("EPFD") limits applicable in the Ku- and Ka-bands. SpaceX has encouraged the development and adoption of such limits, and notes that because there are no legacy satellite systems already operating in V-band, there is an ideal opportunity to develop sensible rules that protect eventual terrestrial links and eventual GSO V-band systems without unduly restricting the next generation of highly advanced NGSO satellite systems proposed in the same bands.

While E-band services are still in early development, SpaceX has also actively promoted the ability for satellite innovation to unfold in the 71-76 GHz and 81-86 GHz portions of the 70/80/90 GHz frequency band. Safeguarding technology innovation for satellite in these bands is particularly timely, given that investment and deployment of satellite technology and NGSO systems is at an all-time high, and such NGSO constellations are poised to bring advanced broadband access services to India, including heretofore unserved and underserved rural areas.

<u>Spectrum Sharing:</u>

Keeping in mind the recognized value of increasing spectrum access for all users, the Government of India has an opportunity to set inventive policies that reward entities that develop and utilize efficient technologies by evolving traditional approaches into those that encourage sharing and reward efficient users. Conceptually, policies like these reward efficient users with greater spectrum availability and penalize inefficient users with higher costs.

With respect to spectrum sharing among NGSO satellite operators, SpaceX has endorsed approaches to encourage development of spectrally efficient technologies. SpaceX supports a band-splitting model for

spectrum sharing among NGSO satellite operators that rewards the system that uses spectrum most efficiently. SpaceX agrees with the ITU and other regulators, including the U.S. FCC, that private coordination between operators is the most efficient means for two NGSO satellite operators to manage shared spectrum. Because operators are best positioned to understand the capabilities of their systems and their business objectives, successful coordination ensures the most efficient use of shared spectrum. Towards that end, SpaceX's band-splitting proposals are designed to drive the best results from those negotiations by encouraging operators to employ technologies and techniques that use spectrum efficiently and to come to quick resolution in their coordination discussions. Ideally, any spectrum policies should primarily set the terms for successful coordination between operators.

With that goal in mind, SpaceX has proposed a default rule under which—absent successful private coordination—two NGSO operators split the spectrum during the specific in-line events that occur between their two systems. To encourage all operators to develop systems better able to share spectrum, the NGSO operator that uses spectrum more efficiently should be awarded first choice of bands to select in the split of spectrum during in-line events. SpaceX notes that the current rule in the United States actually sets the wrong incentives by granting this right of first spectrum choice to the operator that is first to launch a satellite and operate in the frequencies in question, because it encourages operators to quickly launch a small number of satellites without consideration of actual service provision or spectral efficiency, leaving the potential for an inefficient system that hinders any that follow. Instead, a rule that assigns first choice of spectrum to the more efficient NGSO system creates a race-to-the-top in which operators compete to develop the most spectrally efficient technology. This competitive approach would inherently redound to the benefit of Indian consumers, who would accrue better speeds, greater choice and lower costs. And, ultimately, satellite operators that can share with each other are also better able to share with other technologies, such as terrestrial wireless services.

Underlying such proposals is a straightforward principle: aggressive performance metrics set by the regulator, with industry expected to compete with technology and operations that can meet that metric. Given the rapid development of all wireless technologies—terrestrial and satellite—performance-based policies like the one described above will drive more competition than a tax-based system that risks deterring competition and becoming quickly outdated.

Other Considerations

Although SpaceX is not now an active service provider in India with first-hand knowledge of the market's complexities, it commends TRAI for its thorough assessment of unintended and hidden costs and constraints in the deployment of broadband services. Close scrutiny and relaxation of undue regulatory, tax or administrative burdens can accelerate broadband availability and speed deployment from all technology platforms, as noted throughout Section II of the Consultation Paper.

Conclusion

SpaceX appreciates the opportunity to provide comments in response to the consultation. Please do not hesitate to contact us with any questions. We look forward to working with TRAI as we both strive toward a goal of connecting all of India's citizens, enterprises and institutions to high-speed Internet services. Please do not hesitate to contact me at patricia.cooper@spacex.com or +1 202-649-2700 should TRAI seek further information or wish to discuss our comments in greater depth.

Sincerely Yours,

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