Before the
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
DEPARTMENT OF COMMERCE
Washington, D.C. 20230

In the Matter of	)	
REQUEST FOR COMMENTS ON DEVELOPING A SUSTAINABLE SPECTRUM STRATEGY FOR AMERICA'S FUTURE	)	Docket No. 181130999-8999-01

COMMENTS OF SPACE EXPLORATION TECHNOLOGIES CORP.

Space Exploration Technologies Corp. (collectively, "SpaceX"), submits these comments in response to the Department of Commerce National Telecommunications and Information Administration's ("NTIA") request for comments to inform the development of a comprehensive National Spectrum Strategy.[1] SpaceX supports the Administration's efforts to develop a sustainable strategy and agrees that thoughtful planning and long-term predictability are critical to the development of new technologies.

The Administration is correct to respond to the ongoing explosion in demand for both satellite and terrestrial wireless services that is driving technological development and demand for spectrum. A successful National Spectrum Strategy must recognize that to accommodate this demand, all users—Federal, non-Federal, terrestrial, and satellite—must find ways to design and deploy systems that increase efficiency and share limited spectral resources. SpaceX therefore urges the Administration to consider spectrum policies that reward the use of advanced wireless

[1] *See Request for Comments on Developing a Sustainable Spectrum Strategy for America's Future*, Docket No. 181130999-8999-01 (rel. Dec. 20, 2018) ("NTIA Request").

technology that improves spectrum efficiency and enables sharing both within and across platforms.

I. SPECTRUM POLICY SHOULD PROVIDE INCENTIVES TO ALL SPECTRUM USERS—REGARDLESS OF TECHNOLOGY—TO BE EFFICIENT AND TO SHARE.

Experts anticipate that wireless traffic will make up more than 70% of total internet traffic within five years.[2] At the same time, wireless technology is no longer confined to traditional services—reliance on wireless connectivity is now ubiquitous across every industry, from manufacturing to farming and beyond. In fact, some project that in the next five years the total wireless market will consist of only 3% terrestrial 5G devices.[3] The growth in these devices will be vastly outpaced by machine-to-machine devices that will make up over half of all wireless devices.[4] This rapid evolution in the way we use spectrum has the potential to strain and even break traditional terrestrial and satellite policy tools.

To accommodate this evolving demand, both government and industry need to move away from the governmental central planning and stovepipe designations that have characterized past spectrum policy initiatives and toward policies that create incentives for more efficient use of limited spectrum resources. Our National Spectrum Strategy must recognize that spectrum users act like other rational actors—they respond to economic and policy incentives. Therefore, because our goal is to "Increase spectrum access for all users,"[5] our national policies must include inventive means to reward those who develop and use efficient technologies.

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[2] Cisco Visual Networking Index: Forecast and Trends, 2017–2022 (https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html#_Toc529314182) ("Cisco Report").
[3] *Id.* (stating that "5G devices and connections will be over 3 percent of global mobile devices and connections by 2022.")
[4] *Id.* ("By 2022, M2M connections will be 51 percent of the total devices and connections.")
[5] NTIA Request.

While spectrum policy has properly migrated towards emphasizing flexible use of spectrum, too often the technical rules governing these licenses effectively restrict use to specific technologies or use cases. In other instances, bands are explicitly designated for specific uses like fixed or mobile terrestrial services, or fixed or mobile satellite service, designations that will become less meaningful as technologies blend and morph across use cases. In this context, the government starts with the impossible task of predicting consumer demand over the course of the next decade or more and then using those predictions to dictate which technology can access which frequencies.

Not only is this kind of zero-sum directive approach bound to miss its target, it creates the wrong types of incentives for the market. Rather than driving industries to develop more efficient systems, industries are rewarded with exclusive spectrum allocations even when they develop systems that cannot share or they seek broader authorizations than necessary. Instead of creating incentives for efficiency, these policies benefit those who can leverage the allocation process and claim as much spectral real estate as possible.

An effective National Spectrum Strategy would move past this traditional approach and would instead favor policies that encourage sharing and reward efficient users. Policies like these would use the carrot of greater spectrum availability to reward efficient users and to create new potential revenue streams for those who find ways to share. Below are several proposals of these kinds of pro-efficiency policies.

a. A National Spectrum Strategy should include "Sharing Bands" for users who demonstrate an ability to share with other users and other technologies.

Advanced wireless technologies that are either already on the market or on the cusp of introduction are making old-style governmental central planning even less productive. For

instance, new adaptive antennas that allow sophisticated beam forming and steering combined with advanced filtering techniques make it possible for different users and different services to work more precisely and closer together than ever before—both physically and spectrally. Traditional technical rules geared to protect one technology at the expense of another no longer account for this kind of technological advancement. Instead, aging policies have become unnecessarily restrictive and are stalling the surge of innovation.

One way a National Spectrum Strategy could drive the future of efficient spectrum technology would be to reward efficiency with "sharing bands." These bands would not be subject to specific allocations or users, but would be available to anyone who can demonstrate that their systems can safely co-exist with other spectrum users. By designating sharing bands, the government can move away from policy by prediction and can move towards encouraging companies to compete to meet consumer demand, wherever and however it arises. Designated sharing bands reward those who choose to serve consumers through investment in efficient technologies—regardless of the services—with more spectrum than competitors that choose to rely on older and less advanced systems.

b. A National Spectrum Strategy should add "Sharing Rights" and "Satellite Rights" to traditional terrestrial licenses.

In several millimeter-wave bands, the government has already reserved certain portions exclusively for terrestrial and others for satellite uses. But under the right circumstances, these restrictions may be unnecessary for newer satellite systems that rely on advanced technologies that operate more like a wireless network, incorporating phased array antennas and beam steering technology that allows systems to operate side-by-side with terrestrial wireless services. For these systems, a better approach would encourage satellite and terrestrial services to share the band if they can find a way to co-exist.

One way to achieve this goal would be to simply to add a new right to the existing terrestrial license in appropriate circumstances. Specifically, the FCC could add an additional right to certain terrestrial license to allow the licensees to share access to the frequencies covered by the license with satellite operators, so long as both operators agree and do not cause harm to adjacent users. In exchange for the spectrum access, satellite operators could compensate the licensee through financial payments, in-kind exchanges, or other methods agreed to by the parties.

Adding satellite rights to a terrestrial license would create incentives to both satellite and terrestrial providers to develop systems that can operate together without harmful interference. For the terrestrial operator, the additional rights would open up a potential revenue stream for those who can partner with a satellite provider. For the satellite operator, those that invest in advanced technology that can share would be rewarded with an opportunity to increase the spectrum they could use. On the other hand, satellite operators that field inefficient systems like wide, non-steerable beams will have more limited spectrum available to them. Unlike the traditional zero-sum approach to licensing, adding satellite rights to terrestrial licenses creates incentives to both technologies to invest and innovate for more efficient technology.

To be clear, this approach should not—and cannot—supplant allocations for satellite use. Making these additional rights the exclusive method for granting satellite access would give terrestrial users the power and the economic motivation to take anticompetitive steps such as foreclosing satellite access to spectrum. Instead, the additional rights should be included with terrestrial licenses where it can act as an additional incentive for both satellite and terrestrial systems to develop technology that is more spectrally efficient.

c. Policymakers should consider eliminating or de-emphasizing outdated spectrum designations and allocations, such as Mobile Services, Fixed Services, Mobile Satellite Services, or Fixed Satellite Services.

Technological convergence has been accelerating for decades, but the next ten years will likely see the final collapse of the already-falling historical distinction between technologies. Even now, smartphone users are often unaware of whether their device is receiving a signal from a licensed terrestrial mobile wireless service, a satellite service (*e.g.*, GPS), or an unlicensed terrestrial service such as Wi-Fi or Bluetooth linked to a fixed wireless service. While these different signals generally work seamlessly in the background, invisible to the end user, they are nonetheless subject to unnecessarily divergent regulations.

These historical regulatory distinctions are a constraint on future efforts to share spectrum. This year, countries around the world are formulating positions for the upcoming World Radio Conference. Countries will most likely continue to advocate restricting which technologies can use newly available frequencies. But at the same time, agencies in charge of domestic commercial spectrum use, like the Federal Communications Commission, are straining against the constraints of these kinds of artificial designations.

For instance, the Commission currently is finding ways to permit mobile satellite antennas (Earth Stations in Motion) into bands designated for Fixed Satellite Services, rather than in Mobile Satellite Services bands. In fact, the FCC has already determined to allow these moving earth stations—on ships, aircraft, and vehicles—in fixed satellite bands for geostationary satellites. These types of unnecessarily labyrinthine regulations will only increase as technology pushes forward and the distinctions between various services continue to fall away. An enduring National Spectrum Strategy will recognize this convergence and push past these aging and increasingly superfluous designations.

d. Given developments in advanced wireless technology, a forward-leaning National Spectrum Strategy should look skeptically at technologies that are unable to share, especially in high frequency bands.

Traditional spectrum policy tools were developed at a time when service operators using older technologies wanted access to lower frequency bands. These older policies made sense at the time because spectrum at these lower frequencies can propagate large distances and can penetrate obstacles like walls. Technological developments over the past few years are enabling wireless services to move beyond these lower bands into frequencies that would have been unheard of just a few years ago but are now becoming more accessible and technologically viable.

Spectrum allocated in the future will tend to be at these much higher frequencies, called millimeter wave bands. In contrast to their lower frequency counterparts, millimeter waves do not propagate nearly as far and are easily blocked by obstacles like leaves or even rain. Moreover, to move to ever higher frequencies, operators will need to develop advanced antenna and filtering technology.

The physical characteristics of high frequency bands along with developments in technology mean that different services should be able to operate in closer proximity than ever before. For instance, in Ku-, Ka-, and V-band spectrum, satellite antennas pointed skyward should be able to operate nearby downward facing terrestrial antennas with little to no impact.

Yet, despite these developments, advocates still often claim that their preferred service needs its own bespoke allocation and are unable to share with other technologies. Unfortunately, the current all-or-nothing spectrum assignments actually encourages operators to opt for inefficient systems in an effort to claim as much spectrum as possible for themselves. To reverse this trend, policymakers should look skeptically at these claims and embrace policies that

challenge those who design inefficient systems and encourage better use of spectrum resources going forward.

e. An effective National Spectrum Strategy should emphasize vigorous enforcement against spectrum warehousing and refusal to share.

Finally, no ex ante policy will ever be effective without strong ex post enforcement. To prevent warehousing, the National Spectrum Strategy should encourage vigorous enforcement against those who fail to meet build out milestones. But enforcement alone will not prevent warehousing without penalties that outweigh the foreclosure value of preventing competition. For instance, adding satellite rights to terrestrial licenses will be ineffective unless the fine for failure to use the rights is greater than the anti-competitive foreclosure value of sitting on those rights to prevent new entrants into the market.

II. A NATIONAL SPECTRUM STRATEGY THAT ENCOURAGES INNOVATION AND EFFICIENCY WOULD LEAVE NEW BANDS SUCH AS THE V-BAND OPEN FOR ALL DEVELOPING TECHNOLOGY. THE NATIONAL SPECTRUM STRATEGY SHOULD LET DEVELOPMENT AND MARKET FORCES DETERMINE THE BEST USE OF THE BAND RATHER THAT CENTRALIZED CONTROL.

Over the past few years, the FCC restricted satellite access to certain spectrum bands such as the 28 GHz band so that it could auction the spectrum primarily for terrestrial use. During the subsequent auction, a number of highly populated markets drew significant interest from potential licensees and the winning bidders for these licenses will likely deploy services in relatively short order. Yet, despite these successes, well more than one thousand licenses covering large swaths of the country will receive vanishingly small or no bids.[6] These areas will likely remain dormant for services deployment for years.

[6] *See* https://auctiondata.fcc.gov/public/projects/auction101/reports/auction_summary

Going forward, instead of explicitly restricting use of the spectrum and forcing unwanted licenses into a terrestrial auction, a more flexible licensing policy inviting different technologies will encourage more intensive use of the spectrum. For instance, some satellite technologies could have flourished in the lower density markets in the Ka- band, if the rules had been more flexible for other licensing options.

Fortunately, we have an opportunity to allocate spectrum more efficiently for other millimeter-wave spectrum bands in the near future, such as the V-Band. To speed broadband deployment across all technology platforms and to give consumers the opportunity to decide for themselves the services that best meet their needs, spectrum policies should encourage providers of all next-generation technologies to develop and deploy new services expeditiously. The Commission should refrain from choosing one technology over another and should instead adopt rules that provide meaningful opportunities for both next-generation satellite and still-undeveloped terrestrial wireless operations.

Technologies operating in these high frequency ranges—both terrestrial and satellite—are the bleeding edge of wireless innovation. At this early stage, a National Spectrum Strategy would best serve the public interest by allowing all emerging technologies to evolve and compete without choosing a preferred industry at the expense of the potential customers of another. Careful incentives and spectrum allocation policies can spur innovation in viable satellite and terrestrial technology where none currently exists for these higher bands, in turn enabling viable investments into future networks.

For example, instead of prescriptively and unnecessarily limiting satellite service from certain limited frequencies within the V-Band, the Commission should allow satellite deployment wherever satellite providers are able to demonstrate that they can operate below a

specified interference threshold. At the same time, the government should prevent technologies from taking over the band in such a way that prevents other uses.

Despite the existing co-primary allocations for fixed satellite service, fixed terrestrial service, and mobile allocations in the band, much of the V-band, such as the 50.4-51.4 GHz band, is essentially greenfield spectrum that is not actively under development for use by terrestrial wireless operators, and only nascent technological developments are underway to date. In contrast, next-generation satellite broadband providers, including SpaceX, have recently received licenses for operation in this band, and others have applications pending.[7] These satellite providers are also developing new technologies that allow use of this band for, among other things, critical, advanced earth stations to support NGSO satellite constellations that will deliver high-bandwidth, low-latency broadband, to the entire U.S. To provide incentives to both industries to develop new technologies quickly and to design systems that can share with other potential users, the government should not prevent either technology from using the band, so long as one use does not foreclose others.

III. TO FACILITATE EFFICIENT COOPERATION BETWEEN COMMERCIAL AND FEDERAL SPECTRUM USERS, THE NATIONAL SPECTRUM STRATEGY SHOULD EMPHASIZE HIGH DYNAMIC USE AND BILATERAL SPECTRUM SHARING.

To increase availability to spectrum for all users, the Department of Commerce has correctly highlighted that access must be on "a shared basis, through transparency of spectrum use and improved cooperation and collaboration between Federal and non-Federal spectrum stakeholders."[8] To advance this goal, SpaceX supports the efforts of the Office of the Department of Defense Chief Information Officer (DoD CIO) to improve bilateral spectrum

[7] https://www.fcc.gov/document/fcc-boosts-satellite-broadband-connectivity-competition
[8] https://www.ntia.doc.gov/files/ntia/publications/2018-27690_3.pdf

sharing between Federal and commercial spectrum users. As the DoD CIO has recognized, efforts to improve sharing face barriers that tend to be more cultural than technological.[9] Both sides of the Federal/non-Federal divide can bring an ethos antithetical to sharing their spectrum. But over the past several years many users—on both sides—have gradually begun to embrace the reality that to accomplish our various missions, we all will need to move past historic distrust and leverage instead the advanced technology that enables more sharing.

The reality is that the same forces that are motivating the demand for more commercial wireless services are driving the DoD as well. The need for spectrum for warfighting capabilities is growing, but even beyond that direct need, our country is also increasingly vulnerable to Electronic Warfare threats. Electronic equipment that attacks our wireless systems are simultaneously more complex, less expensive, and more available. DoD must have the spectrum resources necessary to combat these forces across multiple spectrum bands.

To achieve the goal set out in the Presidential Memorandum to ensure sufficient spectrum for Federal and non-Federal use, a comprehensive National Spectrum Strategy must set out a flexible framework for bidirectional sharing. This framework should establish high-level principles for sharing that give flexibility to all parties to find solutions to meet their particular situations. And importantly, the principles should lay the groundwork for both short-term and long-term solutions. As the need for wireless resources continues to grow for both commercial and Federal missions, a National Spectrum Strategy should set the foundation for permanent and ubiquitous access for all users.

[9] See Frederick D. Moorefield. DoD Spectrum Evolution Brief to IEEE Broadcast Symposium (Nov. 27, 2017).

IV. A NATIONAL SPECTRUM STRATEGY SHOULD INCLUDE PROVISIONS THAT EASE CONGESTION ON TERRESTRIAL NETWORKS BY ALLOWING ADDITIONAL SPECTRUM FOR RADIOFREQUENCY (RF) BASED INTER SATELLITE LINKS AND TO CONTINUE TO FOREBEAR FROM RESTRICTING OPTICAL CONNECTIONS.

As terrestrial networks become more congested, a National Spectrum Strategy must seek innovative technologies to distribute traffic. For instance, wireless carriers have already been able to ease the strain on their licensed spectrum by offloading more than half their mobile traffic to unlicensed bands through Wi-Fi or LTE-U/LAA. But with global internet traffic forecast to triple over the next five years, the search for new ways to ease congestion cannot end there.

Pioneering inter-satellite communication technology may be another effective solution for the future. Historically, satellites have eased pressure on terrestrial networks, but often data sent to a satellite would immediately return to Earth. With the growth in proposed lower-orbiting satellite constellations, significant development is underway for cross-links between satellites that could deliver data to end users, barely touching terrestrial networks. By traversing these Inter Satellite Links (ISLs), data can land anywhere on Earth by hopping quickly from satellite to satellite rather than being forced back and forth between ground and space.

ISLs are being developed today to operate using either optical or RF technology. Yet, despite the benefits of ISLs and the development of cutting-edge Non-Geostationary Orbit (NGSO) satellite systems, few spectrum bands are available for RF-based NGSO ISLs and the available bands do not have off-the-shelf technologies developed. Once again, a National Spectrum Strategy could avoid the limitations of centrally planned zero-sum allocations by making more room for RF-based ISLs. Making more frequencies available for NGSO ISLs could allow NGSO networks to offload traffic from heavily congested terrestrial networks, thereby resulting in more spectrum available for terrestrial use.

Similarly, an effective National Spectrum Strategy would reaffirm the current effective strategy of leaving optical ISLs unregulated. Because optical systems do not cause interference to RF transmissions, the FCC has expressly forborne from regulating optical ISLs. In this flexible environment, the satellite industry has begun development of new optical, non-RF links both between satellites and from satellites to ground at very high bandwidths. These optical ISLs have the potential to relieve terrestrial networks of huge amounts of data but create no possibility of interference with RF systems. By ensuring the Federal government continues with this effective policy approach, a National Spectrum Strategy would give room for this new technology to flourish.

Beyond just relieving traffic on terrestrial networks, spectrum strategies that foster more inter-satellite links could also allow for more flexibility for future development and increase resilient communications. For instance, some experts project that over the next several years, data traffic and network capacity will move close to the edge of the networks (*i.e.*, closer to the end user).[10] Satellite systems that can carry data from satellite to satellite without having to traverse ground systems can adapt more quickly to these kinds of changing network architectures, ultimately giving networks more flexibility to meet customer demand. Similarly, the adaptive and distributed architecture facilitated by ISLs improves network resiliency by allowing the flexibility for satellite systems to move data outside of an area impacted by a potential disaster.

[10] *See,* Cisco Report at Fig. 25.

V. CONCLUSION

Considering the growth in demand for all things wireless that is driving the acceleration in development of new services, the Administrations is right to focus on creating a long-term National Spectrum Strategy. A sustainable and forward-looking spectrum strategy should emphasize novel policy tools that match the innovative technologies that are revolutionizing wireless use. These new approaches push past the traditional policies designed for old technologies that discourage spectral efficiency in the modern wireless environment. Instead, new ideas like designating "sharing bands" and adding satellite rights to terrestrial licenses will properly reward those who invest in advanced technologies that increase competition. By embracing these types of cutting-edge concepts, a new National Spectrum Strategy can ensure consumers are not anchored by antiquated regulations to one generation of wireless services, but are instead buoyed by technological breakthroughs for generations to come.