

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

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Application of )  
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**SPACE EXPLORATION HOLDINGS, LLC** )  
 )  
For Modification of Authorization for the )  
SpaceX NGSO Satellite System )  
\_\_\_\_\_ )

Call Signs: S2983 and S3018

File No. SAT-MOD-\_\_\_\_\_

**APPLICATION FOR MODIFICATION OF AUTHORIZATION  
FOR THE SPACEX NGSO SATELLITE SYSTEM**

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## SUMMARY

This application marks a continuation of SpaceX's drive to accelerate the deployment of its satellite constellation to deliver high speed, low latency, competitively priced broadband service throughout the United States, and especially to those who live in areas underserved or entirely unserved by terrestrial systems. Through this application, SpaceX seeks authorization to re-space its previously authorized satellites at their existing altitude, with little to no effect on other operators, but to significantly benefit the early availability of broadband service to the unserved and underserved throughout the country. The request does not modify the overall number of satellites, their altitude or inclination, their operational characteristics, or orbital debris considerations.

Earlier this year, the Commission authorized SpaceX to relocate 1,584 of the satellites in its non-geostationary orbit ("NGSO") system to an altitude of 550 km, where they would be able to achieve better performance and orbital debris mitigation characteristics without increasing interference to any other licensed user of the relevant spectrum. While SpaceX began deploying its system by launching the first 60 Starlink satellites on a Falcon 9 earlier this year, it has also verified the efficacy of a deployment approach that allows SpaceX to further accelerate its unmatched deployment schedule, ultimately serving more Americans even sooner. Specifically, based on the successful deployment of its first 60 satellites, SpaceX has confirmed that its groundbreaking deployment process, combined with the capabilities of its satellites and launch vehicle, will allow it to optimize its system with a slight realignment of its already-licensed satellites at their authorized altitudes. This adjustment will accelerate coverage to southern states and U.S territories, potentially expediting coverage to the southern continental United States by

the end of the next hurricane season and reaching other U.S. territories by the following hurricane season.

By adjusting the orbital spacing of SpaceX's already licensed satellites operating at the 550 km altitude, SpaceX can populate more orbital planes with the same number of launches, while decreasing the corresponding number of satellites in each plane and keeping the total number of satellites constant. With this straightforward adjustment, SpaceX can broaden its geographic coverage in the early stages of the constellation's deployment and enable service initiation to serve customers earlier in the middle latitudes and southern-most states, and critically, those often underserved Americans in Hawaii, Puerto Rico, and the U.S. Virgin Islands.

Importantly, SpaceX does not seek with this adjustment to change the overall number of satellites, their altitude or inclination, their operational characteristics, or their orbital debris implications. This incremental modification would not have any material effect on the interference environment for other systems operating in the Ku- and Ka-bands. Nor would it materially alter the space environment for physical coordination with other NGSO systems (including small satellites that lack propulsion in nearby altitudes) or the important work of astronomers to explore the cosmos. The modification would simply re-space SpaceX's existing satellites at their existing altitude, with little to no effect on other operators but to significant benefit for early availability of broadband service throughout the country.

Accordingly, grant of the requested modification will serve the public interest by enabling SpaceX to make efficient use of valuable spectrum resources to provide service more rapidly to more of the Nation, and without adverse effect on other spectrum users. SpaceX currently expects to conduct several more Starlink launches before the end of 2019. SpaceX therefore asks the

Commission to grant the proposed modification expeditiously so that SpaceX can place its satellites into the optimized orbits proposed herein.

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**APPLICATION FOR MODIFICATION OF AUTHORIZATION  
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In this application, Space Exploration Holdings, LLC (“SpaceX”) proposes an incremental modification of its non-geostationary orbit (“NGSO”) satellite system to adjust the orbital spacing of its satellites as currently authorized<sup>1</sup> to accelerate its timetable for providing high speed, low latency, competitively priced consumer broadband service throughout the United States. Notably, SpaceX can accomplish this acceleration to achieve more rapid coverage of U.S. consumers without any change in the number of satellites, their orbital altitude, their inclination, their operational characteristics, or an overall change in interference for any other licensed user of the Ku/Ka-band spectrum. This application identifies all changes that SpaceX requests for its Authorization. SpaceX is also filing an FCC Form 312, Schedule S, and updated technical showings to account for the changes proposed. SpaceX certifies that all other information provided in its Ku/Ka-band applications, as modified, remains unchanged.<sup>2</sup>

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<sup>1</sup> See *Space Exploration Holdings, LLC*, 34 FCC Rcd. 2526 (IB 2019) (“SpaceX Modification”).

<sup>2</sup> See 47 C.F.R. § 25.117(c). See also Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System, IBFS File No. SAT-LOA-20161115-00118 (Nov. 15, 2016); Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System Supplement, IBFS File No. SAT-LOA-20170726-00110 (July 26, 2017); Application for Modification of

## DISCUSSION

The Commission authorized SpaceX in 2018 to construct, deploy, and operate an NGSO constellation consisting of 4,425 satellites operating in 83 orbital planes at five different altitudes, using Ku- and Ka-band spectrum.<sup>3</sup> The Commission granted SpaceX a modification of that authorization in May 2019 to relocate 1,584 satellites previously authorized to operate at an altitude of 1,150 km to an altitude of 550 km. The Commission found that the modification would serve the public interest by improving broadband latency while decreasing the potential for orbital debris. The Commission also noted that the modification reduced the overall number of satellites and did not present significant interference issues.<sup>4</sup>

Once SpaceX received its modified authorization, it moved quickly to deploy by launching its first 60 satellites in a single launch mission on May 23, 2019. Yet, even as SpaceX drives towards its unprecedented deployment tempo, its iterative process has allowed for further optimization of the same satellites to accelerate broadband service for more Americans.

Through extensive study of orbital formations and spacecraft performance, SpaceX has identified and employed a system deployment approach that will provide robust broadband service to more Americans more quickly. SpaceX has demonstrated the effectiveness of its revolutionary deployment process and confirmed its ability to populate three orbital planes with a single launch. By then reorganizing its satellites at their already authorized altitude, SpaceX can place coverage and capacity more evenly and rapidly across more of the U.S., accelerating broadband service to middle and southern states, as well as to Hawaii, Puerto Rico, and the U.S. Virgin Islands.

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Authorization for the SpaceX NGSO Satellite System, IBFS File No. SAT-MOD-20181108-00083 (Nov. 8, 2018).

<sup>3</sup> See *Space Exploration Holdings, LLC*, 33 FCC Rcd. 3391, ¶ 11 (2018) (“SpaceX Initial Authorization”).

<sup>4</sup> See SpaceX Modification, *supra* note 1.

Specifically, rather than placing all satellites from a given launch in the same orbital plane, this new spacing would enable SpaceX to populate three different orbital planes from a single launch. This dispersion accelerates the process of deploying satellites covering a wider service area.

As summarized in Table 1, the modification simply increases the number of orbital planes from 24 to 72 with a commensurate decrease in the number of satellites in each plane from 66 to 22.<sup>5</sup>

Parameter	Current Authorization	Proposed Modification
Orbital Planes	24	72
Satellites Per Plane	66	22
Total Satellites	1,584	1,584
Altitude	550 km	550 km
Inclination	53°	53°

**Table 1. Summary of Proposed Modification**

**I. GRANT OF THE PROPOSED MODIFICATION WOULD SERVE THE PUBLIC INTEREST**

In granting SpaceX’s last modification request, the Commission noted that Section 25.117 governs the modification of space station licenses, and that the rule provides that such applications “will be granted” except in two limited circumstances:<sup>6</sup> either when the modification involves a request for additional bandwidth or when it would not serve the public interest.<sup>7</sup> As in the prior

<sup>5</sup> As mentioned above, SpaceX has already launched a tranche of satellites that are currently operating in compliance with its existing authorization. SpaceX requests that any modification granted in this proceeding include authority to reposition those satellites as appropriate to come into conformity with the newly authorized orbital parameters.

<sup>6</sup> See SpaceX Modification, ¶ 7.

<sup>7</sup> *Id.* (citing 47 C.F.R. § 25.117(d)(2)(ii) and (iv)).

modification, SpaceX does not request any increase in bandwidth, so the application should be granted so long as it serves the public interest. As discussed below, the modification serves the public interest by accelerating deployment of service to unserved and underserved Americans and yields a greater degree of broadband competition for more Americans.

#### **A. The Proposed Modification Would Enable SpaceX to Accelerate Initiation of Broadband Service Throughout the United States**

Under its current authorization, SpaceX already has an unprecedented and unmatched deployment plan that would provide continual coverage over northern states after as few as six more launches. To introduce initial broadband service from an NGSO system—just like a terrestrial network—an operator must deploy a sufficient number of nodes to ensure continuous coverage of the service area. And just as with terrestrial mobile networks, the system must have enough antennas in the right physical configurations to hand off signals. But in the case of NGSO systems, rather than the customers moving from tower to tower, the satellites themselves are moving and must be optimally spaced to cover customer locations as each satellite proceeds over the horizon.

The orbital shell currently authorized at 550 km deploys the initial satellites with concentrated coverage and capacity over the latitudes near 50 degrees North and South, then progresses toward the Equator with subsequent deployments. Despite the already unprecedented speed of SpaceX's deployment, the remainder of the country could require up to six further launches over several more months for continuous service coverage.<sup>8</sup>

As Table 1 illustrates, the proposed modification would change very little of SpaceX's current authorization. What *would* change significantly is SpaceX's ability to begin offering

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<sup>8</sup> See Caleb Henry, *Musk says Starlink "economically viable" with around 1000 satellites*, SPACE NEWS (May 15, 2019), <https://spacenews.com/musk-says-starlink-economically-viable-with-around-1000-satellites/>.

robust broadband service to more of the country and the world. The proposed respacing would require fewer launches of satellites—perhaps as few as half—to initiate service to the entire contiguous United States (as well as Hawaii, Puerto Rico, the U.S. Virgin Islands, American Samoa, and the Northern Mariana Islands). Globally, the modification would enable more rapid coverage of all longitudes to grow toward the Equator, as well as bolstering capacity over in areas of greater population density.

As the Commission has recognized, many communities across the United States and the world lack access to reliable broadband connectivity, and therefore are unable to participate fully in economic, social, and civic activities.<sup>9</sup> Chairman Pai has noted the importance of this issue, as well as the role of next-generation satellite systems in addressing it.

My top priority as Chairman of the FCC is closing the digital divide. I've often said that in order to bring digital opportunity to all Americans, we need to use all of the tools in the toolbox. Satellite broadband service is one of those tools. . . . Next-generation satellites are bringing new competition to the broadband marketplace and new opportunities for rural Americans who have had no access to high-speed Internet access for far too long. That's why the FCC under my leadership has moved quickly to give a green light to satellite innovators.<sup>10</sup>

SpaceX shares Chairman Pai's resolve, and requests this modification to accelerate the deployment of an NGSO system capable of initiating service throughout the entire continental U.S., Hawaii,

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<sup>9</sup> See, e.g., *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, 33 FCC Rcd. 1660, ¶ 50 (2018) (noting that “over 24 million Americans still lack fixed terrestrial broadband at speeds of 25 Mbps/3 Mbps,” and that “the gap in rural and Tribal America remains notable: 30.7 percent of Americans in rural areas and 35.4 percent of Americans in Tribal lands lack access to fixed terrestrial 25 Mbps/3 Mbps broadband”). Internationally, the disparities between broadband access and absence are even greater, with 4.2 billion people (or 57% of the world's population) offline. See 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), <http://broadbandcommission.org/Documents/publications/HLPF-July2016.pdf>. See also BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, “The State of Broadband 2015,” at 8 (Sep. 2015), <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)).

<sup>10</sup> Ajit Pai, Chairman, FCC, Keynote Address at the Satellite Industry Association's 21<sup>st</sup> Annual Leadership Dinner at 2 (Mar. 12, 2018), <https://www.fcc.gov/document/chairman-pai-remarks-satellite-industry-association-dinner>.

Puerto Rico, the U.S. Virgin Islands, American Samoa, and the Northern Mariana Islands. This sense of urgency propels SpaceX's ongoing technological innovation generally and the optimization of this proposed modification specifically, to bring the substantial benefits of robust broadband service to all these areas sooner.

### **B. SpaceX Will Achieve These Public Interest Benefits Without Offsetting Concerns**

In making its public interest determination, the Commission must weigh the benefits of a proposal against any offsetting concerns to see where the balance of interests lies. As discussed above, the modification will lead to significant benefits of faster initiation of service for more customers in more areas of the United States. And as discussed below, the proposed modification would achieve those benefits without creating offsetting issues.

First and foremost, the Commission has recognized that a modification should be granted where it “does not present any significant interference problems and is otherwise consistent with Commission policies.”<sup>11</sup> In this case, the respacing of existing SpaceX satellites will not have a significant impact on other users of the Ku- and Ka-band spectrum. To demonstrate this fact, SpaceX has included in the Technical Attachment submitted with this application several analyses of the interaction between its system as modified and other licensed systems in the band.

- First, to assess the potential impact on other NGSO systems authorized in the first Ku/Ka-band processing round, SpaceX presents an analysis that considers the dynamic, time-varying interference expressed as a cumulative distribution function (“CDF”) of the interference-to-noise ratio (“I/N”), for varying percentages of time. The I/N CDF is

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<sup>11</sup> *Teledesic LLC*, 14 FCC Rcd. 2261, ¶ 5 (IB 1999). *See also The Boeing Co.*, 18 FCC Rcd. 12317, ¶ 7 (IB 2003) (“In recognition of the length of time it takes to construct a satellite system, the rapid pace of technological change, and the goal of promoting more efficient use of the radio spectrum, the [Commission] has granted such requests in cases where the proposed modification presents no significant interference problem and is otherwise consistent with Commission policies.”).

derived from a time-domain simulation of the two NGSO systems over a long enough time to produce meaningful statistics. The analysis considers the effect on two NGSO systems hypothetically operating in the Ku-band (OneWeb and Kepler) and two in the Ka-band (Telesat and O3b). That analysis demonstrates that the modification would have a negligible effect on other NGSO systems, and that any initial effect would be ameliorated as SpaceX continued to deploy its constellation.

- Second, to ensure harmonious operations with GSO satellite systems, SpaceX will continue to comply with applicable EPFD limits.<sup>12</sup> The Technical Attachment includes an updated analysis confirming such compliance.
- Third, SpaceX's operations will also continue to satisfy the condition imposed to protect terrestrial fixed services operating in a portion of the Ka-band.<sup>13</sup> The Technical Attachment includes an updated analysis confirming compliance with the applicable protection criteria.

These analyses confirm that there is no reason to anticipate any significant interference issue arising from the proposed modification.

SpaceX recognizes that some parties have in the past raised issues that extend beyond radiofrequency interference. For example, some small satellite operators have worried that SpaceX's operations would constrain their ability to deploy systems in orbital altitudes below 600 km, given that they typically do not include propulsion on their satellites, meaning their satellites

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<sup>12</sup> See 47 C.F.R. §§ 25.108(c)(3) and (9), 25.146(c) (incorporating ITU Radio Regs., Article and 22). The Commission has found these limits sufficient to prevent harmful interference to other spectrum licensees. See, e.g., *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, ¶¶ 39, 72 (2000) ("the single-entry and aggregate EPFD limits we are adopting also define the level of acceptable interference from a NGSO FSS system into a GSO FSS system under our rules").

<sup>13</sup> See SpaceX Initial Authorization, ¶¶ 35 and 40q.

have little collision avoidance capability to avoid conjunctions with others.<sup>14</sup> As the Commission recognized in granting the SpaceX Modification, because SpaceX has invested in propulsion for its satellites, collision risk is considered to be zero (or near zero). In any event, SpaceX is subject to an ongoing obligation to coordinate its physical operations with other NGSO systems (as are the other NGSO operators, including those without propulsive capabilities) and will also be subject to any additional obligations arising from the Commission’s pending rulemaking on orbital debris mitigation.<sup>15</sup>

Lastly, after SpaceX launched its first sixty satellites, some in the optical astronomy community voiced concern that the light reflected from those satellites could interfere with their ability to observe the cosmos.<sup>16</sup> While no established guidelines or standards exist for acceptable levels of reflection from spacecraft, SpaceX has nonetheless reached out to U.S. and international astronomy organizations and observatories to measure scientifically the actual impact of its satellites upon deployment and on-orbit configuration, and to explore potential avenues for amelioration if appropriate.<sup>17</sup> Here again, there is no reason to believe that respacing the satellites would have any material impact on this ongoing analysis of reflectivity (albedo), but SpaceX remains committed to working with the astronomy community to achieve a mutually satisfactory resolution.

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<sup>14</sup> See Comments and Petition to Defer (“CSSMA Comments”); Petition to Defer (“Astro Digital Petition”); Petition to Defer (“Planet Labs Petition”); and Petition to Defer (“Spire Petition”). All these filings were submitted in IBFS File No. SAT-MOD-20181108-00083 on January 29, 2019.

<sup>15</sup> See SpaceX Modification, ¶ 22.

<sup>16</sup> See, e.g., Shannon Hall, *After SpaceX Starlink Launch, a Fear of Satellites That Outnumber All Visible Stars*, NEW YORK TIMES (June 1, 2019), <https://www.nytimes.com/2019/06/01/science/starlink-spacex-astronomers.html>.

<sup>17</sup> As noted by SpaceX founder and CEO Elon Musk, “we’ll make sure Starlink has no material effect on discoveries in astronomy. We care a great deal about science.” Elon Musk (@elonmusk), TWITTER (May 27, 2019, 12:11 AM), <https://twitter.com/elonmusk/status/1132907207463321600?lang=en>.

## CONCLUSION

By authorizing a small change in the spacing of satellites in one shell of the SpaceX constellation, the Commission can accelerate the initiation of broadband service across the country, including in areas with no viable high-speed broadband alternative. Moreover, it can achieve this result without any material impact on other spectrum users, space safety, or astronomical observation. For the foregoing reasons, and for the reasons set forth in the accompanying materials, SpaceX requests that the Commission find that granting the requested modification to revise the spacing of satellites in the lower shell would serve the public interest, and issue such grant expeditiously.

Respectfully submitted,

**SPACE EXPLORATION HOLDINGS, LLC**

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