Before the
National Telecommunications and Information Administration
Washington, DC 20230

In the Matter of	)	
	)	
Developing a Sustainable Spectrum Strategy for America's Future	)	Docket No. 181130999–8999–01
	)	

COMMENTS OF SPIRE GLOBAL, INC.

Spire Global, Inc. ("Spire") is pleased to respond to the Request for Comments ("RFC") in the above-captioned docket. Spire is a leading player in the small satellite (or smallsat) market, operating a state-of-the-art satellite-based meteorological monitoring,[1] maritime monitoring,[2] aircraft monitoring,[3] and hosted payload service.[4] Spire currently operates seventy-

[1] Spire's satellites currently perform GPS-Radio Occultation. GPS-Radio Occultation measures GPS transmissions that pass through the atmosphere. The magnitude of the refraction in the transmission will vary based on the temperature and water vapor concentration in the atmosphere. This measurement of the refractions will allow for enhanced weather forecasting models. *See, e.g.*, Anthony J. Mannucci *et al.*, *Generating Climate Benchmark Atmospheric Surroundings Using GPS Radio Occultations*, NASA (Jul. 2007), http://1.usa.gov/1bOUxEI.

[2] The satellite system will monitor Automatic Identification System ("AIS") and Application Specific Messages ("ASM") signals and provide critical near real-time data of interest to shipping companies, harbor operators, governments, vessel traffic service data providers, and financial services companies. Maritime vessels with gross tonnage of 300 tons or more are required by international law to carry AIS transmitters. *See* The International Convention for the Safety of Life at Sea, Nov. 1, 1974, 32 U.S.T. 47, 1184 U.N.T.S. 3 (Dec. 2002 Amendments); *see also Application Specific Messages collection*, e-Navigation, http://www.e-navigation.nl/asm (last visited Nov. 11, 2016) (noting that water levels, marine traffic signals, tidal windows, and clearance time to enter port information can be passed through ASM transponders). For example, ASM transponders mounted on the Panama Canal locks can emit signals to nearby ships alerting them as to the open/close status of the canal. *See, e.g.*, *id.*

[3] Spire provides aircraft monitoring of ADS-B signals to help aircraft carriers meet regulatory mandates, including those promulgated by the Federal Aviation Administration, and to help complete a critical part of the U.S. Next Generation Air Transportation System. *See Airsafe*, Spire, https://spire.com/data/aviation/ (last viewed January 20, 2019).

[4] Spire's satellites are built to accept new payloads quickly, allowing for an incredibly fast rollout of new capabilities. Spire has a launch already booked for nearly every month for the next 12-18 months. By leveraging Spire's existing schedule, clients get access to nearly every reasonable launch heading to a LEO orbit. *See Bespoke Sensors*, Spire, https://spire.com/data/custom-platform/ (last viewed January 20, 2019).

two (72) LEMUR-2 non-geostationary satellite orbit ("NGSO") satellites on orbit.

In response to the Federal Communication Commission's ("Commission's") recently released Notice of Proposed Rulemaking titled "Streamlining Licensing Procedures for Small Satellites," the Commercial Smallsat Spectrum Management Association addressed ways to improve federal/non-Federal spectrum sharing and future smallsat spectrum considerations.[5] Spire supports these responses and provides the relevant excerpts in the attached Annex as they respond to questions 2, 5, 6, and 7 in the RFC.

Respectfully submitted,

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[5] *See* Comments of Commercial Smallsat Spectrum Management Association, IB Docket No. 18-86 (filed July 9, 2018). *See generally Streamlining Licensing Procedures for Small Satellites*, IB Docket No. 18-86, Notice of Proposed Rulemaking, FCC 18-44 (rel. Apr. 17, 2018) ("*Smallsat NPRM*").

Annex

Compatibility and Sharing with Federal Users (pp. 37-40)

[M]any of the bands needed by small satellites are bands shared on a co-primary basis between non-Federal and Federal users, so a productive and open-minded approach on both sides is necessary to realize the potential of small satellites in the United States. CSSMA's response here is informed by the experience of its members, which have coordinated with Federal agencies under Part 25. Much more can be done to share the lower frequency bands where sharing is truly more challenging. CSSMA believes there are still further opportunities to improve the efficiency of the coordination process.

CSSMA believes one or more of the following solutions could be implemented to make coordination between Federal users and small satellite applicants more efficient and successful.

1) A database, on a band-by-band basis, should be put together and should reflect the "knowable" information about spectrum usage in each band. CSSMA's members do not find the existing NTIA Government Spectrum Compendium and Use Reports to be complete (or updated) with all the information required for coordination.[6] The database CSSMA proposes should include information collected about both Federal and non-Federal systems. It should include, but not be limited to, information regarding the funding status of the programs (both Federal and non-Federal), launch and key activity dates, basic technical information regarding bandwidths, channelization plans, ground station locations (both domestic and foreign), and basic G/T and EIRP information. It should be updated regularly. Access to the database should be made available to Federal employees and contractors who have a need to know it and to non-Federal applicants[.]

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[6] *See generally Federal Government Spectrum Use Reports 225 MHz – 7.125 GHz*, NTIA, *https://www.ntia.doc.gov/page/federal-government-spectrum-use-reports-225-mhz-7125-ghz* (last visited July 2, 2018).

Such a database, with open access, would foster a far more efficient and effective coordination process.

2) Mandatory pre-coordination meetings should take place between applicants and representatives of all affected Federal agencies. CSSMA would recommend this meeting takes place shortly after the filing of an application with the Commission, ensuring that Federal agencies are only pre-coordinating serious applications for which the application fee has been paid. It will also provide potentially months of time for pre-coordination. The NTIA and Commission representatives dealing with the related applications should be invited and encouraged to come to such meetings. Minutes should be kept and should be reviewed by all parties present, and copies should be made available to the Commission and NTIA personnel involved in the related license application(s). These pre-coordination meetings will facilitate a more rapid closure on coordination matters. [S]tandard pre-coordination meetings would help ease burdens on Federal agencies.

3) As CSSMA mentions above, formal coordination should begin concurrently with public notice, so that formal coordination can potentially be completed concurrently with the public notice period.

4) For pre-coordination and formal coordination, CSSMA requests that such meetings operate under a principle that time-is-of-the-essence and that a reasonable schedule be maintained for the resolution of coordination activities, leading to a positive and timely outcome. Failure of Federal agencies to act in a timely manner truly does prejudice commercial companies by causing missed launches and lower service levels to customers and missing time to market advantages.

But, in the end, if there is not a meaningful change to the coordination process (such that there is a free flowing exchange of system requirements and specifications and applications are coordinated in a timely manner), then CSSMA's recommendation in these cases regarding these critical bands (where non-Federal users have co-equal rights to the same spectrum resource) is to divide the band into sub-bands with one sub-band available exclusively to the Federal side of the United States Table of Frequency Allocations and one sub-band available exclusively to the non-Federal side of the United States Table of Frequency Allocations.

Furthermore, CSSMA notes that these discussions involving such shared bands ignores the reality that all of the shared bands under discussion are also allocated, on the same primary basis, by all other administrations of the world. The length of the NTIA coordination process and the effect of a non-concurrence by NTIA in precluding an ITU filing both can have the effect of prejudicing a United States company's ability to establish international spectrum rights.

Methods of Sharing (pp. 41-44)

[…] CSSMA believes that it is potentially time to consider some major adjustments to how users share lower frequency satellite spectrum (VHF and UHF bands). Many radio regulations reflect thinking from many decades ago, and technology has changed by many orders of magnitude since that time. The current ITU coordination process tries to prevent spectrum warehousing but can often have the opposite effect. What if a channel is not owned for a time; rather, it is borrowed for a time? In this age, it is now possible to digitally and dynamically adapt the needs of users (even commercial operators, which can share a channel among several operators on some non-permanent basis). Such approaches are not new and have been used with the mobile services. Below CSSMA suggests multiple means by which sharing could occur, increasing the efficiency and utility of the spectrum.

1) *Regional Sharing*: Assuming the majority of users of these bands are NGSO-like (and specifically not GSO systems) a region can be defined as an area on the Earth's surface with a diameter such that all the channels within a band can be spatially shared and reused

again (*i.e.*, one satellite in one region would not see an Earth station in another region). For instance, for a 500 km NGSO satellite, there might be approximately ten such regions around the Earth. This method of sharing, while presenting issues at the regional boundaries, is the easiest notional means of sharing. Sharing in this manner is all about working out the boundary conditions satisfactorily.

2) *Spatial Sharing:* Reusing a channel by minimizing in-line interference via directive beam antennas, at low frequencies, is limited to Earth station beam sizing. While many Federal systems may have Earth stations with relatively wide beams[7] in UHF bands, commercial small satellite[] systems could find it acceptable to use narrower beams and relatively low power levels in both directions to perform TT&C satellite functions. In fact, the directivity of such stations may not be entirely necessary to complete the required links, but this directivity might allow sharing with a co-channel Federal system by minimizing in-line interference events. This method would work particularly well at higher frequencies.

3) *Frequency and Time Sharing*: FDM and time division multiplexing ("TDM") are both common techniques used today including in some VHF/UHF bands. Examples include the FDM channelization of the VHF for terrestrial use by the military[8] and between ORBCOMM Inc ("ORBCOMM") and National Oceanic and Atmospheric Administration ("NOAA") in the 137-138 MHz band.

4) *Third Party Automated Coordination/Honest Broker*: Conceivably, there could be a third-party "honest broker," which coordinates the transmission times between many operators using a private database of satellite system information and arbitrates incoming

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[7] TIROS, ARGOS, and GOES user uplinking antennas are examples.
[8] For example, in the frequency band 148-150.05 MHz, the United States military has adopted a 30 kHz channel spacing, and the Canadian military uses a 25 kHz channel plan.

transmission schedule requests between operators, thus allocating transmission frequency and time slots in a manner that optimizes the capacity for all the operators within their needs.[9] Such a system could even account for the priority and preemptive access needs of critical systems.[10] Many small satellite operators already employ the services of a ground system provider who serve many missions and these providers may be ideally situated to offer such a brokering service. CSSMA believes that by using the honest broker concept and by using priority and preemptive access to assure link availability to high value or highly critical services, such a sharing process is clearly in the public interest as it optimizes the number of operators that can share the spectrum, and it greatly enhances spectral efficiency (*e.g.*, bits/Hz and temporal channel occupancy).

5) *Code division multiple access ("CDMA") and Random Multiple Access Sharing*: CDMA is another very valuable method of sharing spectrum particularly for the higher frequency bands given the bandwidth limitations of the lower bands. There are, as well, many types of Random Multiple Access ("RMA") sharing possible that can have a

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[9] CSSMA notes that the honest broker is a lot like the software technology used by GSO systems (such as Inmarsat) to assign traffic to their FDMA channels. The method used is known as a Demand Assignment Multiple Access ("DAMA") system. A DAMA system, primarily, receives requests for service from subscribers and assigns their terminals to FDMA channels on a first-come, first-served basis. So, in this proposal, the honest broker is performing a DAMA function *within* AND *between* multiple systems. Demands for traffic assignments come with a priority ranking number ("PRN") attached (for simplicity, it can be a number between 0 and 9). A PRN of 9 might be given, for instance, to a Federal user that has traffic to send involving the safety and regularity of the flight of an aircraft, and a priority ranking number of 0 might be given to a commercial container at sea that reports its temperature and position once per day. Traffic is then prioritized by the UTC time it was received by the honest broker and its PRN. Higher-numbered PRNs are given higher priority in the assignment queue once the spectral band begins to approach its time-frequency capacity limit. When the system is at lower fill levels, the priority ranking number can be ignored as all requests can all be satisfied. Notice that while CSSMA assumes in this scenario that the flow of traffic is handled by an independent and by separate satellites with potentially different purposes, it is also possible for Federal and non-Federal users to share a common satellite in this manner.

[10] The Federal Aviation Administration's Future Aeronautical Navigation Systems Working Group-3 studied a priority based multiple access system. This approach has great merit here.

particularly important role to play for bands shared with land mobile terrestrial users and small satellites.[11]

Other Bands For Consideration (pp. 54-58)

[…] [In addition to the MSS, EESS, MetSat, and SOS allocations in VHF, UHF, and lower S- band,] CSSMA believes that the most important bands to the small satellite community are as listed in Table 4. Many CSSMA members are actively using these bands at the moment or, in some instances, have filed applications for licensing within these bands.[12] […]

Table 4: Other Bands and Regions of Spectrum Potentially Beneficial or Critically Important to Small Satellites

Frequency Band	Link Direction	Suggested Category of Service
Short Duration NGSO	(Earth-to-space) (space-to-Earth)	MSS, SOS, EESS
1525.0-1535.0 MHz	(space-to-Earth)	MSS, SOS, EESS
1535.0-1559.0 MHz	(space-to-Earth)	MSS, SOS, EESS
1613.8-1626.5 MHz	(Earth-to-space)	MSS, SOS, EESS
1626.5-1660.0 MHz	(Earth-to-space)	MSS, SOS, EESS
2483.5-2495.0 MHz	(space-to-Earth)	MSS, SOS, EESS (non-imaging)
2495.0-2500.0 MHz	(space-to-Earth)	MSS, SOS, EESS (non-imaging)
8025-8400 MHz	(space-to-space)	EESS, FSS, Meteorological Satellite Service

[11] *See infra* Annex 1 (description of the dynamic channel assessment and assignment system ("DCAAS") method).
[12] *See supra* note 2.

Frequency Band	Link Direction	Suggested Category of Service
20-150 GHz	Both link directions	EESS, FSS, MSS, SRS, SOS

For the reasons set forth below, the Commission [and NTIA] should explore all of these bands for use by small satellites.

Short Duration NGSO: Working Party 7B Agenda Item 1.7 is considering the allocation of additional SOS spectrum for Short Duration NGSOs[.][13] Still, if such spectrum is made available in WRC-19, it should certainly be considered by the Commission [and NTIA.]

1525.0-1535.0 MHz: This band is allocated co-primary to MSS and EESS in all three ITU regions.[14] CSSMA notes that the United States has not picked up the EESS service category domestically. While CSSMA understands this band is used, in part by Inmarsat, there may be opportunities to implement sharing with GSO systems.

1535.0-1559.0 MHz: This E-s band is the primary GSO band for MSS downlinks.[15] As the *Smallsat NPRM* has identified MSS as a potentially favorable compatible service category, it seems plausible that sharing could occur in this band between GSO and NGSO systems given appropriate technical sharing rules being put in place.

[…]

[13] *See* ITU-R Resolution 659, Studies to accommodate requirements in the space operation service for non-geostationary satellites with short duration missions (2015), https://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C
0A00000C0007PDFE.pdf.
[14] *See* 47 CFR § 2.106.
[15] *See id*.

1626.5-1660.0 MHz: This s-E band is the primary GSO band for MSS uplinks.[16] It seems even more likely to CSSMA that this band could be shared with small satellite systems using directive antennas directed away from the GSO arc. This band is often paired with the 1535.0-1559.0 MHz band.

2483.5-2495.0 MHz and 2495.0-2500.0 MHz: Taken together, these are the companion s-E NGSO MSS (Big LEO) bands. CSSMA wonders if sharing arrangements, particularly in the upper 5 MHz (where, in the end, Iridium did not go), might be able to be reached with mobile services. Solutions like the DCAAS system mentioned […] could be implemented.

8025-8400 MHz: CSSMA believes the Commission [and NTIA] should also enable greater use of spectrum by adding space-to-space allocations in X-band between 8025-8400 MHz. The 8 GHz earth-exploration band, popularly used for remote sensing satellite downlink, is not allocated for space-to-space links. If the 8025-8400 MHz allocation was made to mirror the similar remote sensing bands in lower S-band (2025-2110 MHz and 2200-2290 MHz) in terms of having the allocation to both space-to-Earth as well as space-to-space, greater use of remote sensing satellites and more innovation would be possible. Additionally, opening up a band that is already used by many operators of high-data operations like remote sensing would allow them to use their same hardware and thus make it more accessible given the severe space and power constraints that limit the ability to add additional communication modules on small satellites.

20 – 150 GHz (Millimeter Wave Bands): This region of the spectrum is critical to realizing the full promise of small satellites. Millimeter wave frequency bands enable small, lower cost space systems. For this reason, CSSMA requests that small space systems be given some preferential treatment when it comes to the allocation of spectrum to new systems and services in the millimeter wave portion of the domestic and ITU tables of frequency allocations. CSSMA

[16] *See id.*

urges the Commission [and NTIA] to consider the allocation of one to several bands in the 20-150 GHz region of the spectrum for use particularly (but not necessarily exclusively) for small space systems. CSSMA wishes to point out that despite their size and mass, such small systems are capable of highly accurate attitude control. Precise pointing of a spacecraft structure itself or various gimbal mechanisms fitted to the platform is not only possible but is common-place now with small space systems. To be specific, they have the full flexibility and accuracy of much larger satellites. And, typically, they are even more responsive (in terms of time to acquire a new attitude, target, or position) than their larger counterparts. Hence, they can be tasked to point highly directive, narrow beam antennas at receiving or transmitting target locations on the Earth's surface. To the extent that small satellite antennas can form narrow beams, coordination should be imminently feasible. Frequency reuse through spatial isolation resulting from high gain/highly directive antennas, placed on satellites in the cubesat class and their Earth stations, is now a reality. Several systems, doing exactly these tasks, are in-orbit now. However, forming narrow beams on small objects requires the exploitation of very short wavelength emissions (*i.e.*, millimeter wave frequency band use).