Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20054

In the Matter of	)	
	)	
AST&Science LLC	)	
	)	File No. _____
Petition for Declaratory Ruling Granting	)	
Access to the U.S. Market for a	)	
Non-U.S.-Licensed Non-Geostationary	)	
Orbit Satellite Constellation	)	

PETITION FOR DECLARATORY RULING

Sallye Clark
Laura Stefani
Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C.
701 Pennsylvania Ave, NW
Washington, DC 20004
(202) 434-7300

Counsel for AST&Science LLC

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EXECUTIVE SUMMARY

AST&Science ("AST") is an innovative start-up satellite company, founded with the goal of providing cost-effective, high-speed wireless broadband services throughout the country, serving all Americans, regardless of where they live, work, or travel. AST's constellation will bridge the rural digital divide, helping carriers fulfill their nationwide 5G coverage obligations, even in places without terrestrial infrastructure. AST will accomplish this by working with carriers to ensure that, where a customer device cannot connect to a wireless carrier's terrestrial base station, it can still access the network via AST's satellite system. This arrangement allows carriers to augment and extend their coverage by using their own spectrum resources without having to build towers or other infrastructure where it is not cost-justified or is difficult due to environmental challenges. It also allows carriers to maintain services to customers during emergencies where events interrupt the operations of their terrestrial networks, as the AST technology requires very little terrestrial infrastructure. This proposal requires no grants of new spectrum, nor any involuntary spectrum sharing: instead, it expands the utility of already licensed spectrum, without causing harm to other users, in large part because the same licensee engages in satellite-terrestrial coordination.

AST, based in Midland. TX, with an additional office in College Park, MD, recently closed a very successful Series B funding round. AST's new financial partners are the Vodafone Group, Rakuten, American Tower, and Samsung Ventures, who follow Series A investor Cisneros, based in Miami, and founder and CEO Abel Avellan. To date AST has raised $128M, which will fund the next test satellite, AST's build out of its satellite manufacturing facility, and the launch of the first phase of satellites.

AST has been building a satellite production facility in Midland, TX to enable what ultimately will become a 243 spacecraft low earth orbit ("LEO") constellation operating in sixteen orbital planes at approximately 700 km orbital altitude. In this application, AST is seeking U.S. market access for its SpaceMobile constellation, which is licensed by the telecommunications authority of Papua New Guinea. AST seeks use of V band frequencies for gateway communications. AST additionally seeks use of its satellite system on certain LTE frequencies.

Grant of this application clearly will serve the public interest, as it will aid the Federal Communications Commission ("FCC") in achieving a major policy goal of access to high quality broadband service throughout the United States, both to the private sector and to government users. AST can provide universal broadband access directly to customer handsets and any LTE or 5G enabled device, without any modifications or the use of special chipsets, and without the buildout of any additional terrestrial wireless infrastructure. In this way, the AST system will enable the more efficient use of already-licensed spectrum, increasing the number of users able to access broadband and the amount of coverage that spectrum allotment provides without imposing involuntary sharing or otherwise limiting the spectrum rights of any other licensee. It will allow carriers to maintain their services, including to first responders, during times of natural disasters and other emergencies.

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PETITION FOR DECLARATORY RULING

AST&Science LLC ("AST"), through counsel, files this Petition for Declaratory Ruling seeking authorization for access to the U.S. market for SpaceMobile, its novel satellite constellation. This Petition is filed pursuant to Section 25.137 of the Federal Communications Commission's ("FCC" or "Commission") rules.[1/] AST has a license to operate its non-geostationary ("NGSO") constellation under the authority of the government of Papua New Guinea, and it intends to launch initial portions of its constellations in 2021, with the complete constellation for U.S. coverage launched and operational by early 2023. As part of its petition for U.S. market access, AST additionally seeks waivers of certain FCC rules. As demonstrated in this Petition, there is good cause to grant AST's application, which will provide for substantial public benefits by allowing for the provision of universal broadband services throughout the United States using existing spectrum in cooperation with existing licensed terrestrial users.

I. GRANT OF THIS PETITION WILL SERVE THE PUBLIC INTEREST

AST is a U.S.-based company with a manufacturing and operations facility in Midland, Texas, and a research and development facility in Maryland. AST is working to develop an ultra-powerful, space-based broadband network that will connect directly to off-the-shelf user terminals and equipment everywhere. The network will afford customers a cost-effective, high

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1/ 47 C.F.R. § 25.137. *See also Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Second Report and Order, 30 FCC Rcd 14713 (2015) ("Part 25 Reform Order") and *Amendment of the Commission's Space Station Licensing Rules and Policies*, First Report and Order, 18 FCC Rcd 10760 (2003) ("*Space Station Licensing Reform Order*").

data-rate communications service available in all parts of the U.S., and around the globe, supplementing coverage by licensed users and making more efficient use of spectrum resources. AST has filed this Petition seeking a ruling to permit its satellites to provide service in the United States.

A. Description of Services

AST's NGSO SpaceMobile satellite network will provide access to new wireless broadband services throughout the contiguous United States, as well as in Alaska, Hawaii, Puerto Rico, the U.S. Virgin Islands and all U.S. territories using off-the-shelf, unmodified user equipment such as LTE mobile phones.[2/] This will constitute a major step forward in bridging the digital divide by allowing for universal broadband access at lower costs than ever before, regardless of available terrestrial infrastructure. In geographic areas where it is currently cost-prohibitive to provide wired or terrestrial wireless broadband service due to population density, topography, or land-use issues, licensees could provide high-quality broadband coverage from AST's satellites, bringing the benefits of broadband to every American, everywhere. In this way, the SpaceMobile constellation will aid in meeting the demands for rural broadband connectivity and wireless service, something high on the Commission's agenda. FCC Chairman Pai has repeatedly made clear during his tenure that his "highest priority would be making sure every American who wants Internet access can get it."[3/] AST expects its SpaceMobile system to begin operations in the United States by early 2023.

A robust satellite broadband service also will support numerous first responder applications. Beyond the capacity to provide for direct communications for first responders, fast and reliable satellite broadband can serve as back-up to wireless networks during disasters and support first responder IoT solutions as well as the operation of Unmanned Aircraft Systems ("UAS"). AST's SpaceMobile network will ensure that first responders can connect to their colleagues and to the wireless network, supporting voice, video and data regardless of location or the functionality of the terrestrial network. SpaceMobile will provide the same end-user

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2/ SpaceMobile will have the ability to provide services to mobile phones using 2G, 3G, 4G, LTE, and 5G networks.

3/ Ajit Pai, *Bridging the Digital Divide*, FCC BLOG (July 13, 2017, 2:25 PM), https://www.fcc.gov/news-events/blog/2017/07/13/bridging-digital-divide.

experience and high-quality broadband coverage for rural responders as what is available to those in urban areas.

In terms of potential customers, AST has secured partnership agreements with almost a dozen global mobile network operators to offer services in conjunction with their networks, which will support acceleration of the deployment of 5G service to consumers.[4/] Many of AST's partners have invested in AST or collaborated with it in order to ensure that it is fully compatible with their networks and equipment. AST's proposed use of its constellation will enhance competition in the communications marketplace by providing alternative connectivity, as well as ensuring that participating carriers can compete across the entire country, even where they lack terrestrial infrastructure. So far, AST has raised $128 million in initial investments, and it is working with telecommunications companies around the globe to build out a complete network.

B. Description of Network Architecture

The proposed system will consist of a LEO satellite constellation, SpaceMobile, operated by earth stations located within and outside the United States, and off-the-shelf user terminals and equipment such as a cellphones, tablets or LTE broadband modems operated in coordination with licensed carriers.[5/] All necessary technical and operational characteristics are described fully in the Form 312, the attached Schedule S, and the Technical Statement (Attachment A) accompanying this application. AST provides a summary here.

i. Space Segment

The AST system will consist of 243 satellites operating in sixteen orbital planes in an approximate altitude of 700 kilometers. SpaceMobile will begin launch in 2021. AST anticipates that the constellation will have 18 satellites in the initial stage, located in the equatorial plane, and total 243 in the final stages. Ultimately, the constellation will provide for full global coverage. The satellites will use beamforming technology and allow the utilization of MIMO functions, and will be fully compatible with existing terrestrial infrastructure.

4/ AST will not be providing common carrier services.

5/ As per Commission policy, applications for earth station authorizations will be filed separately, ether by AST or its partners.

The AST system will operate under filings made by Papua New Guinea with the International Telecommunications Union ("ITU"). Papua New Guinea has issued AST a license to operate its satellite system.[6/]

Presently, AST is performing testing using a small sat, BlueWalker 1, and plans to launch BlueWalker 3 in 2021 for additional testing. Additional information regarding the spacecraft is provided in the Schedule S and the Technical Statement that accompany this application.

ii. Ground Segment

The AST ground system will consist of three main categories of earth stations: 1) one main earth station in Midland, TX, which will be used as a gateway station; 2) gateway stations located both in the United States and around the world; and 3) off-the-shelf user terminals (wireless devices), which will link directly with AST satellites.[7/] In the United States, AST's secondary gateway stations will be co-located at already existing facilities; AST will seek Commission authority separately to operate from these facilities.

AST is not seeking licensing of user terminals through this application. The user terminals will operate on LTE spectrum authorized to AST's partner operators[8/]

II. AST'S APPLICATION MEETS THE CRITERIA FOR U.S. MARKET ACCESS

The Commission provided for U.S. market access by non-U.S. licensed satellites through a regulatory framework established in its DISCO II Order.[9/] The Commission's analysis of whether an application for U.S. market access should be granted considers the effect of AST's proposed system on competition in the United States; spectrum availability, eligibility requirements and operating requirements; and national security, law enforcement, foreign policy, and trade.[10/]

6/ *See* Attachment B (License from Papua New Guinea).

7/ S band Telemetry, Tracking and Control ("TT&C") will be conducted at facilities located outside of the United States. V band operations will be performed from AST United States facilities.

8/ Interference within these frequency bands will be self-managed. Outside of these bands, out-of-band emissions ("OOBE") from the AST system will be comparable to those of the terrestrial systems already licensed to AST's partners.

9/ *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, Report and Order, 12 FCC Rcd 24094 (1997) ("*DISCO II Order*").

10/ *See id.*

A. Effective Competition

The Commission's DISCO II decision adopted a framework where the Commission would provide a presumption in favor of market entry for applicants licensed by World Trade Organization ("WTO") members in lieu of requiring a showing of effective competition in the licensing country.[11] The presumption in favor of market entry applies to this application. As noted above, the AST system was authorized by Papua New Guinea's ("PNG") telecommunications regulatory authority, the National Information Communications Technology Authority ("NICTA"). PNG is a member of the WTO, and the Commission previously has granted U.S. market access to satellites operating pursuant to an authorization from PNG.[12/] Satellite services covered by the WTO Basic Telecommunications Agreement include both fixed satellite service ("FSS") and mobile satellite service ("MSS").[13/] AST is seeking authority to provide satellite services that are covered services under that agreement.[14/] Therefore, AST's application is entitled to the presumption by the Commission that market entry will satisfy the "competition" portion of the required public interest analysis.

Moreover, it is well-established that new competitors and services in the U.S. satellite services market "will provide U.S. consumers with additional choices among providers, reduce[] prices, and increase[] the quality and variety of services."[15/] Grant of the application clearly would enhance competition, as it would allow a new service offering to U.S. consumers, particularly those consumers who have no wireless or broadband service available today. Allowing the AST system entry into the U.S. market certainly will provide for all of these benefits, in line with the Commission's long-standing policy goals.

11/ *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, First Order on Reconsideration, 15 FCC Rcd 7207 (1999) ("*DISCO II Recon Order*").

12/ *Satélites Mexicanos, S.A. de C.V., Letter of Intent to Access the U.S. Market Using a Non-U.S. licensed L-Band Radionavigation Satellite Service Satellite at the Nominal 117 W.L.° Orbital Location*, Order, Call Sign S2926, IBFS File No. SAT-LOI-20140617-00070 (Aug. 20, 2015); *Loral Spacecom Corporation, Petition for Declaratory Ruling to Add Telstar 13 to the Permitted Space Station List*, Order, DA No. 03-2624 (Aug. 8, 2003).

13/ *DISCO II Order* at ¶ 30.

14/ AST does not seek to provide direct-to-home, Direct Broadcast Satellite ("DBS") or Digital Audio Radio Service ("DARS") services.

15/ *DISCO II Order* at ¶ 41.

B. Spectrum Availability

In this application, AST primarily seeks access to V band frequencies for use as gateway links. AST additionally seeks access to select nationwide LTE frequencies for satellite connectivity, with the permission of partner spectrum holders. AST's spectrum use will be coordinated through submissions already submitted to the ITU.[16/] AST will comply with all applicable domestic and international requirements for coordinating operations in the relevant frequency bands. As detailed below, and in further detail in the attached Technical Statement,[17/] AST will be able to operate on these frequencies without creating a risk of harmful interference to U.S.-licensed satellite and terrestrial systems. Protection of terrestrial services in the V band will be ensured by compliance with power flux density ("PFD") limits. AST additionally recognizes that protection of GEO satellites must be ensured according to specific rules that will be developed by the ITU-R as a result of decisions by WRC-19. Protection of NGSO systems will be ensured by coordination, also as a result of WRC-19 decisions.

Table 1 – AST Requested Frequencies

FREQUENCY BAND	**USE**
37.5-42.5 GHz	Gateway links (downlink)
45.5-47, 47.2-50.2, and 50.4-51.4 GHz,	Gateway links (uplink)
Select 3GPP frequencies licensed nationwide to partners[18/]	User equipment

i. Gateway Frequency Bands

AST will use V band frequencies for critical gateway links, as detailed below. The gateway uplink carriers in the V band accommodate and uplink the mobile phone forward link signals for each active cells to AST's SpaceMobile satellites. The satellite payload processer demultiplexes the V band uplink signals and maps them to the downlink beams covering the cells formed by the phased array antenna in the assigned mobile phone channel frequencies. At the return link side, the user equipment uplink signals from different cells in the assigned mobile phone channels are received by the formed beams from the phased array antenna on the

16/ *See* Section III(B)(i) below.

17/ *See* Technical Statement, Attachment A at A.6, A.7 and A.10.

18/ AST expects such licenses would be in the 617-960 MHz and 1710-2200 MHz frequency ranges, and possibly others.

SpaceMobile satellite. The received signals are multiplexed in frequency domain, up-converted to the V band downlink frequencies, and transmitted to the gateway station.

37.5-40 GHz: The Commission has allocated the 37.5-40 GHz band to FSS on a co-primary basis, permitting licensing of individual FSS earth stations in the band subject to certain interference protection obligations that serve to provide for sharing with Upper Microwave Flexible Use Service ("UMFUS") wireless licensees.[19/] AST will comply with the Commission's mechanisms for band sharing with UMFUS licensees.

40-42.5 GHz: The Commission has allocated the 40-42 GHz band for FSS use as a downlink band,[20/] a decision that it recently reaffirmed.[21/] Operations in this band will be in conformance with the Commission's rules and the Table of Frequency Allocations. Therefore, AST's operations would not create the potential for interference to other U.S.-licensed terrestrial or satellite systems, and AST may deploy gateway stations on these bands without waiver or operating restrictions.

Regarding 42-42.5 GHz, this portion of the band is allocated to wireless (UMFUS) licensees in the United States. Therefore, AST seeks a waiver of the Commission's rules and the Table of Frequency Allocations to the extent necessary to allow for non-conforming use of the band. Access to this additional spectrum will provide AST with the flexibility to better handle gateway link anomaly and redundancy without sacrificing throughput. AST will operate under this waiver on a non-interference, non-protected basis to the wireless licensees. AST will operate under this waiver on a non-interference, non-protected basis to the wireless licensees. The protection of wireless licensees from satellite transmissions also will be ensured by the fact that AST will comply with the ITU Article 21 power flux density ("PFD") limits for this band, as noted in the attached Technical Statement.[22/]

45.5-47 GHz: In the United States most of this band is allocated to Federal and Non-Federal users on a shared basis for mobile, MSS (uplink) and Radionavigation satellite. 46.9-47 GHz is additionally allocated to fixed non-Federal use. AST seeks a waiver of the Part 25 rules

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19/ 47 C.F.R. § 2.106.

20/ *Id.*

21/ *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration and Memorandum Opinion and Order, 32 FCC Rcd 10988, ¶ 192 (2017).

22/ *See* Technical Statement at A7.

and the Table of Frequency Allocations to operate on a non-conforming basis on this band. AST will operate under this waiver on a non-interference, non-protected basis to other users in the band.

47.2-48.2 GHz: The Commission has allocated the 47.2-48.2 GHz band for FSS uplink use on a co-primary basis. AST's proposed use of the band is consistent with the Commission's rules and the Table of Frequency Allocations. Therefore, AST's operations would not create the potential for interference to other U.S.-licensed terrestrial or satellite systems, and AST may deploy gateway stations on these bands without waiver or operating restrictions.

48.2-50.2 GHz: The Commission has allocated the 48.2-50.2 GHz band for FSS use on a primary basis. AST's operations in this band will comply with the Commission's rules and the Table of Frequency Allocations. Therefore, AST's operations would not create the potential for interference to other U.S.-licensed terrestrial or satellite systems, and AST may deploy gateway stations on these bands without waiver or operating restrictions.

50.4-51.4 GHz: The Commission allocates the 50.4–51.4 GHz band on a co-primary basis with fixed and mobile licensees.[23/] AST will comply with the Commission's mechanisms for band sharing required with UMFUS licensees.

ii. LTE Bands

To the extent necessary, AST seeks authority to connect its constellation with user terminals that may operate on 3GPP spectrum licensed on a nationwide basis to its partners, for example on certain portions of 617-960 MHz and 1710-2200 MHz.[24/]

iii. Spectrum Compatibility

Prior to commencing operations, AST will conduct frequency coordination with other users (Federal and non-Federal) in accordance with the relevant provisions of the FCC rules and the ITU radio regulations. AST's system is capable of sharing the requested frequencies with other NGSO V band satellite systems. In addition, the system's sharp, beamforming technology will control leakage of LTE band signals and allow it to successfully share with other users. For

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23/ *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Fifth Report and Order, 34 FCC Rcd 2556, ¶¶ 10-12 (2019).

24/ AST recognizes that certain services within these frequency ranges are protected in various ways. AST will not seek authority to operate on these protected bands, but will only seek to connect its satellites to user terminals that operate on frequencies already licensed by its partners for mobile use on a nationwide basis.

bands to be used by user equipment, AST is working with licensees and will manage frequency coordination with them on a self-interference basis.

C. Additional Issues (National Security, Law Enforcement, Foreign Policy, and Trade)

The Commission also considers the issues of national security, law enforcement, foreign policy, and trade in evaluating requests for U.S. market access, but notes that these generally arise only in "rare circumstances."[25/] In this instance, AST's application does not raise any concerns related to these issues. For this reason, this element is satisfied as well.

III. AST WILL MEET THE COMMISSION'S ELIGIBILITY, OPERATIONAL AND OTHER REQUIREMENTS

As demonstrated in the Form 312, this Petition, the supporting Technical Statement, and the Schedule S, AST meets the legal, technical and other qualifications required of applicants for space station licenses issued by the Commission, which also apply to those seeking U.S. market access.[26/]

A. Legal and Technical Qualifications

i. Legal Qualifications

AST is presumably legally qualified to provide its proposed satellite service in the United States. Members of AST's management team have decades of experience in the space and satcom industries, and the company employs more than 120 space scientists and engineers, many of whom have prior experience with satellite builds and deployment. AST is majority controlled by U.S. citizens and has no foreign government ownership or control. Additionally, neither AST nor its owners have ever engaged in any violations of U.S. law or the Commission's rules.

ii. Ownership Information

AST is a privately held entity that is majority owned and controlled by a U.S. citizen. AST has attached an exhibit to Form 312 providing the required information concerning its owners, directors and 10% or greater shareholders.

25/ *DISCO II Order*, ¶ 180.

26/ 47 C.F.R. § 25.137; *see also Space Station Licensing Reform Order*.

iii. Technical Qualifications

AST has completed and attached a form Schedule S, which the Commission requires for applicants to provide technical qualifications for a non-U.S. satellite system. Additionally, AST's system will comply with the equivalent power flux density limits specified in Article 22 of the Radio Regulations. This requirement therefore is met.

B. Additional Requirements

i. ITU Requirements

As mentioned above, AST has worked through Papua New Guinea's telecommunications regulatory authority to initiate the notification process at the ITU for its requested frequencies for the SpaceMobile constellation. AST has made the following filings to the ITU:

1. MICRONSAT API
2. MICRONSAT API MOD-1
3. MICRONSAT API MOD-2 (in the backlog)
4. MICRONSAT CR
5. MICRONSAT CR MOD-1
6. MICRONSAT CR MOD-2
7. MICRONSAT CR MOD-3 (in the backlog)
8. MICRONSAT Notification for S and Q/V Bands of API and API MOD-1.

ii. Milestones and Bond Requirements

The Commission's rules require that NGSO systems authorized to operate in the United States place space stations into the assigned orbits, and operate 50% of their authorized constellation within six years of grant of the authorization and 100% within nine years.[27/] AST will comply with these milestone requirements.

The Commission also requires that non-U.S. license satellite operators post bonds for payments in the event that the systems fail to meet the milestones.[28/] AST will post the required bond within thirty days of the grant of this Petition, and will thenceforth comply with the escalating bond requirements.

27/ 47 C.F.R. § 25.164(b).

28/ 47 C.F.R. § 25.165.

iii. End of Life Disposal and Orbital Debris Mitigation

AST's constellation is subject to direct and effective oversight by NICTA, Papua New Guinea's regulator, of its orbital debris mitigation. In particular, Papua New Guinea follows all ITU rules and regulations for orbital debris mitigation, and will specifically require AST to dispose of the satellite in accordance with all relevant ITU recommendations, and in a manner that minimizes risk to operating satellites and or other international agreed standards. Therefore, AST believes that this alone satisfies the Commission's required showing regarding orbital debris mitigation plans.

Nonetheless, AST understands the Commission's desire to understand orbital debris implications related to its decision to allow for U.S. market access. For this reason, AST has prepared a report that is attached to this Petition at Attachment C, which sets out the end of life disposal plans and other orbital debris information regarding its constellation.[29/] In terms of satellite failure, the report shows that the satellites are designed to accept a high level of impact failure, contain trackable components, and can use propulsion to avoid collision to avoid debris.[30/] The report also demonstrates that orbital debris mitigation will be handled by successful reentry, using propulsion to change altitude and feather in a manner that will not pose a risk to human lives.[31/]

C. Processing Round Procedures (Section 25.157)

The Commission expressly provides for consideration, on a case-by-case basis, regarding the entry of new NGSO FSS applicants outside of its processing rounds. In its NGSO Order, the Commission explained that:

> The purpose of the recent processing rounds was to establish a sharing environment among NGSO systems, to provide a measure of certainty in lieu of adopting an open-ended requirement to accommodate all future applicants. At the same time, it is uncertain how many of the pending system applications will proceed to full deployment. **While we will initially limit sharing under the ΔT/T of 6 percent threshold to qualified applicants in a processing round, treatment of later applicants to approved systems must necessarily be case-by-case based on the situation at the time**, and considering both the need to protect existing expectations and investments and provide for additional entry as

29/ Anticipated lifetime is 7-10 years.

30/ *See* Attachment C.

31/ *Id*.

> well as any comments filed by incumbent operators and reasoning presented by the new applicant.[32/]

The Commission also adopted Section 25.261, which sets out spectrum sharing rules for NGSO FSS systems.[33/] This new spectrum access regime for NGSO FSS systems relies upon spectrum sharing in lieu of its older competitive consideration regime. In this way, the Commission struck a balance between providing access to new entrants while preserving spectrum use by processing round participants. For these reasons, it is appropriate for the FCC to consider this application at this time.

To the extent necessary, AST requests waiver of the processing round rules.[34/] The Commission may waive any rule for good cause shown.[35/] Generally, FCC grants waivers of the processing round rules "based on the applicants' demonstrations that they can avoid interference events through means such as scheduling of transmissions, and also that they would not preclude future entrants from using the same spectrum."[36/] In particular, grant of a waiver is appropriate where the particular facts make strict compliance with the rule inconsistent with the public interest.[37/] In making this decision, the Commission considers factors such as hardship, equity, and more effective implementation of its overall policy.[38/] Here, waiver of the rules to allow for a case-by-case review of AST's request for market entry would serve the public interest, as the Commission's spectrum sharing regime and good faith coordination among operators will assure sufficient access to spectrum.

In particular, a waiver would not undermine the purpose of Section 25.157(c), which is to provide for competitive market entry of FSS NGSO entrants, as AST will comply with the spectrum sharing requirements of Section 25.261 and AST will engage in good-faith coordination with authorized and future NGSO systems. Therefore, waiver of the processing

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32/ *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 7809, ¶ 61 (2017) ("*NGSO FSS Order*") (emphasis added).

33/ 47 C.F.R. § 25.261.

34/ 47 C.F.R. § 25.157(c).

35/ 47 C.F.R. § 1.3.

36/ *See Streamlining Licensing Procedures for Small Satellites,* Report and Order, 2019 FCC LEXIS 2148 at n. 232 (2019).

37/ *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

38/ *See WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969); *Northeast Cellular*, 897 F.2d at 1166.

round rule would be consistent with the purpose and intention of the processing round procedures, which is to provide for the appropriate sharing of spectrum resources. Here, AST's system is an NGSO system communicating with "earth stations with directional antennas anywhere in the world under a Commission license, or in the United States under a grant of U.S. market access."[39/] AST recognizes that NGSO operators are required to coordinate their shared use of spectrum,[40/] and AST will coordinate the use of commonly authorized frequencies in good faith and follow the default procedure when required.[41/] The Commission previously has waived its processing round rule under similar circumstances.[42/]

Importantly, the systems presently authorized to operate in the V band are still in the early stages of development and are not fully engaged in their use of these frequencies. In fact, several participants of the initial V band processing round now will not be providing their requested services.[43/] Given the relatively small size of the proposed AST constellation, the fact that its use of the V band will be solely for gateway service and not for end user connectivity, and the now reduced numbers of constellations using these frequencies, AST believes that appropriate sharing can be achieved. Indeed, other applicants for the V band agree that sharing is not only possible but also in the public interest. For instance, OneWeb has noted that "[p]ermitting multiple systems to operate on the same V-band spectrum, with appropriate

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39/ 47 C.F.R. § 25.261(a).

40/ *See NGSO FSS Order*, ¶ 45.

41/ 47 C.F.R. § 25.261(b), (c).

42/ *See, e.g., Swarm Technologies, Inc. Application for Authority to Deploy and Operate a Non-Voice, NonGeostationary Lower Earth Orbit Satellite System in the Mobile-Satellite Services*, Memorandum Opinion, Order and Authorization, DA 19-1044, Call Sign S3041, IBFS File No. SAT-LOA20181221-00094 (Oct. 17, 2019) (granting waiver of the processing round rules for entity that will only use a fraction of the allocated spectrum); *Northrop Grumman Space & Mission Systems Corporation*, Order and Authorization, 24 FCC Rcd 2330, ¶¶ 26-29 (2009) (granting wavier of the processing round requirements because operations, in a highly elliptical orbit, would preclude interference to other operators); *Space Imaging, LLC, Petition for Clarification of Amendment of the Commission's Space Station Licensing Rules and Policies*, Declaratory Order and Order and Authorization, 20 FCC Rcd 11964, ¶¶ 10-11 (2005) (granting waiver of the processing round requirement because doing so would not preclude other operators from operating in the bands).

43/ *See The Boeing Company Withdraw Request*, Call Sign S2966, IBFS File No. SAT-LOA-20160622-00058 (withdraw date July 31, 2018) (withdrawing application for V band authority); *LeoSat MA, Inc*, DA 19-1158A1, Call Sign S2979, IBFS File No. SAT-PDR-20161115-00112 (Oct. 31, 2019) (determining that grant of U.S. market access was null and void for failure to meet bond requirement).

coordination, would promote efficient use of spectrum and effective competition and would help close the digital divide by making high-speed broadband available at competitive prices in remote areas."[44/]

For these reasons, the Commission should consider AST's application outside of the V band processing round or, in the alternative, grant AST waiver of its processing round rules.

D. Additional Requests for Waiver

AST seeks several additional waivers to facilitate authorization of its novel system.

i. Section 25.112(a)(3)

Section 25.112(a)(3) provides that the Commission will dismiss applications that request authority to operate space stations in bands not allocated internationally for the requested operations under the ITU Radio Regulations.[45/] To the extent necessary, AST seeks waiver of this rule. The Commission adopted this rule to prevent parties from filing applications that would serve as "placeholders" for future service, while the applicant pursued changes at the ITU to permit the service.[46/] That concern does not apply to the present application, as AST intends to use the requested frequencies in the near future.

ii. 25.155(b)

To the extent necessary, AST seeks waiver of the mutual exclusivity rule in Section 25.155(b).[47/] This rule historically has allowed applications for NGSO-like satellite systems to undergo comparative consideration with one or more mutually exclusive applications "only if the application is received by the Commission in a condition acceptable for filing by the 'cut-off' date specified in a public notice."[48/] For the same reasons discussed *supra* in Section III.C regarding the Commission's processing round rules, waiver of the mutual exclusivity rule would also be in the public interest.

44/ *WorldVu Satellites Limited Petition for Declaratory Ruling Granted Access to the U.S. Market for the OneWeb V-Band System*, IBFS File No. SAT-LOI-20170301-00031, at 30 (filed March 1, 2017).

45/ 47 C.F.R. § 25.112(a)(3).

46/ *Space Station Licensing Order* at 10809.

47/ 47 C.F.R. § 25.155(b).

48/ *Id*.

iii. Section 25.156(d)(4)

Section 25.156(d)(4) requires consideration of applications for feeder link and service band authority to be made separately.[49/] AST seeks waiver of this requirement so that all of its requests may be considered in the same application. Grant of the waiver is in the public interest, as it would facilitate a more efficient review and processing of AST's application for U.S. market access. There is no reason to separate the decisions, and doing so could only result in unnecessary delay.

IV. CONCLUSION

AST's innovative design and technologies are poised to provide next-generation satellite LEO wireless broadband service to customers, offering reduced costs, improved service, and full nationwide coverage via existing mobile phones and maximum spectrum efficiency. As demonstrated in this Petition, and in all of the accompanying materials, AST fully satisfies the Commission's requirements for U.S. market access. Therefore, the Commission's prompt grant of AST's application would serve the public interest.

Respectfully submitted,

BY: /s/ Sallye Clark
Sallye Clark
Laura Stefani
Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C.
701 Pennsylvania Ave, NW
Washington, DC 20004
(202) 434-7300
Counsel for AST&Science LLC

April 9, 2020

49/ 47 C.F.R. § 25.156(d)(4).

SPACEMOBILE NON-GEOSTATIONARY SATELLITE NETWORK
Technical Statement

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A.1 SCOPE AND PURPOSE

This Technical Statement has been prepared in support of AST's application for U.S. market entry of its space stations, and supplements the technical information provided in the Schedule S in accordance with the requirements of 47 C.F.R. § 25.114 and other relevant sections of the Federal Communications Commission's ("FCC" or "Commission") rules. In its application, AST is seeking access to 37.5-42.5, 45.5-47, 47.2-50.2, and 50.4-51.4 GHz for gateway stations, and to select 3GPP frequencies licensed nationwide to its partners.[1/]

A.2 BASIC TECHNICAL INFORMATION

AST seeks access to the U.S. market for SpaceMobile, a non-geostationary satellite ("NGSO") system that will serve the public interest by providing for expanded coverage of terrestrial

1/ *See* Petition for Declaratory Ruling at 6.

mobile services to partner operators. As described in greater detail below, the AST system will provide this capability using feeder link gateways operating in the FSS V bands.

A.2.1 Space Segment

The AST low earth orbit ("LEO") constellation will consist of 243 satellites organized into 16 orbital planes of 15 satellites per plane, except for the equatorial orbit, which will have 18 satellites. The satellites will be deployed in altitudes ranging from 725 to 740 km, and the inclined orbits will have angles of inclination of either 40 or 55 degrees, as detailed in the Schedule S that accompanies this application.

The AST satellites each will have up to 2800 user beams and two or three gateway beams. Each user beam will be electrically steered through a large phased array antenna and will be capable of being pointed anywhere within the Field of View ("FoV") of 20 degrees elevation angle. Each of the gateway beams is mechanically steered and capable of being pointed anywhere within the FoV of 10 degrees elevation angle. Each satellite in the AST constellation will provide service up to 58 degrees away from boresight (nadir).

An illustration of the coverage footprint of each satellite is in Figure 1 below.

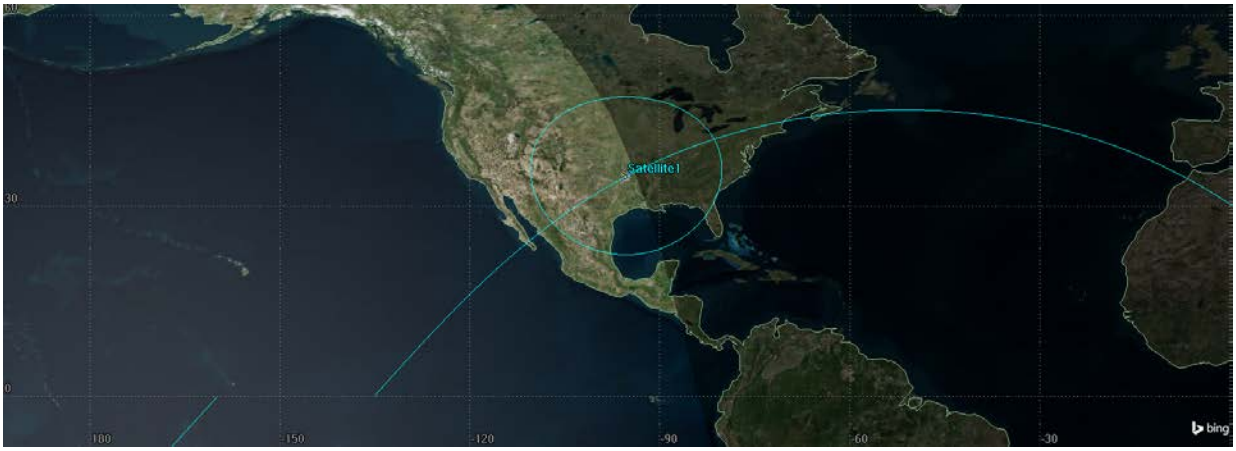

Figure 1 – Typical Satellite Footprint

A.2.2 Spectrum

The satellites will be capable of operating in the following frequency bands:[2/]

a) For service links in the Earth-to-space direction
663-915 MHz
1710-2010 MHz
3410-3490 MHz
3700-3980 MHz

b) For service links in the space-to-Earth direction
617-960 MHz
1805-2200 MHz
3510-3590 MHz
3700-3980 MHz

c) For gateway/feeder links in the Earth-to-space direction
45.5-47 GHz
47.2-50.2 GHz
50.4-51.4 GHz

d) For gateway/feeder links in the space-to-Earth direction
37.5-42.5 GHz

e) For space operations in the Earth-to-space direction
410-475 MHz
1980-2010 MHz
2025-2110 MHz

f) For space operations in the space-to-Earth direction
410-475 MHz
2170-2290 MHz
2483.5-2500 MHz

In accordance with Section 25.114(c)(4)(i) of the Commission's rules,[3/] the actual bandwidth used for the telecommand carriers will be 64 kHz to 256 kHz using circular polarization.

A.2.3 Channelization Plan and Spectrum Use

Each user beam will have up to four channels, using any combination of channel bandwidths of 10 MHz, 5 MHz, 3 MHz, or 1.4 MHz in the bands allocated to 3GPP services in the U.S, within

[2/] These frequencies are illustrative of the system's capabilities worldwide, and differ from the authority requested from the FCC in AST's Petition for Declaratory Ruling.
[3/] 47 C.F.R. § 25.114(c)(4)(i).

617 MHz to 960 MHz, 1710 MHz to 2200 MHz, or 3410 MHz to 3980 MHz, respectively. Each satellite may transmit all of its active user beams on the same frequency or different frequencies. Each active user beam will track a fixed cell on the ground within its FoV without steering the boresight of the planar phased array antenna. All of the active beams can be distributed flexibly within the FoV. The same cell on the ground can be illuminated by a single beam, by multiple beams from same satellite, or by multiple beams from different satellites within the view of the cell to enhance the user experience. The beam-to-beam handover and the gateway handover are based on schedules and use a "break-then-make" approach.

A.3 PREDICTED SPACE STATION ANTENNA GAIN CONTOURS

Service Links: SpaceMobile will transmit and receive in the service link frequency bands using independently and electrically steerable beams with 41 dBi gain and sidelobe patterns conforming to ITU-R Recommendation S.672-4 with L_N better than -28 dB.

Gateway Beams: All gateway link spot beams from each satellite will be independently and mechanically steerable over the view of Earth at a 10 degrees elevation angle. For the feeder links, SpaceMobile will use receive steerable beams of 48.4 dBi gain and transmit steerable beams of 47.5 dBi gain, with sidelobe patterns conforming to ITU-R Recommendation S.672-4 with L_N equal to -20 dB. The space operation receive and transmit beams in the UHF band will be fixed, omnidirectional, with 0 dBi gain.

TT&C Beams: The space operation receive and transmit beams in the S band – used only outside of the U.S. –will be fixed, with 6 dBi gain and sidelobe patterns conforming to ITU-R Recommendation S.672-4 with L_N equal to -10 dB. Communication to and from the TT&C earth stations will operate at an elevation above the local horizon of 10 degrees or higher. Each TT&C beam will support one command channel and one telemetry channel with the channel bandwidth of between 64 kHz and 256 kHz.

A.4 OVERALL DESCRIPTION OF SYSTEM FACILITIES, OPERATIONS AND SERVICES

Users will use off-the-shelf equipment, such as smartphones operating in the LTE bands, for communicating through the SpaceMobile system. All user equipment will operate on frequencies already licensed to AST partners.

The gateway uplink carriers in the V band accommodate and uplink the wireless downlink signals for each active cell to the AST SpaceMobile satellite. The satellite payload processer demultiplexes the V band uplink signals and maps them to the downlink beams covering the cells from the phased array antenna in the assigned wireless network channel frequencies.[4/] At the return link side, the user equipment uplink signals from different cells in the assigned wireless network channels are received from the phased array antenna on the SpaceMobile satellite. The received signals are multiplexed in frequency domain, up-converted to the V band downlink frequencies, and transmitted to the gateway station.

The V band gateway earth stations will use 4.8 m or larger antennas, depending on the gateway locations and the particular rain rates. Two gateway earth station antennas are required to operate each satellite. Multiple gateway stations may be collocated at each gateway site.

AST's S band TT&C operations will communicate with the spacecraft from locations outside of the United States. On-orbit nominal operation will be conducted through the in-band channel in the V band frequencies via the V band gateway station. AST will monitor TT&C operations from its system control center located in Midland, Texas, and will conduct routine TT&C from international locations distributed worldwide.[5/] The control center and the earth station connections are via a dedicated Ethernet.

Transmissions will be conducted through simple frequency translation transponders on board the satellite. Figure 2 below shows the architecture of the system in its final phase.

4/ SpaceMobile will be able to communicate with user equipment operating on 2G, 3G, 4G, LTE, and 5G networks.

5/ AST's facility in College Park, MD will serve as a secondary control center, though no antennas will be located at this site, which will receive links via fiber from the Midland facility.

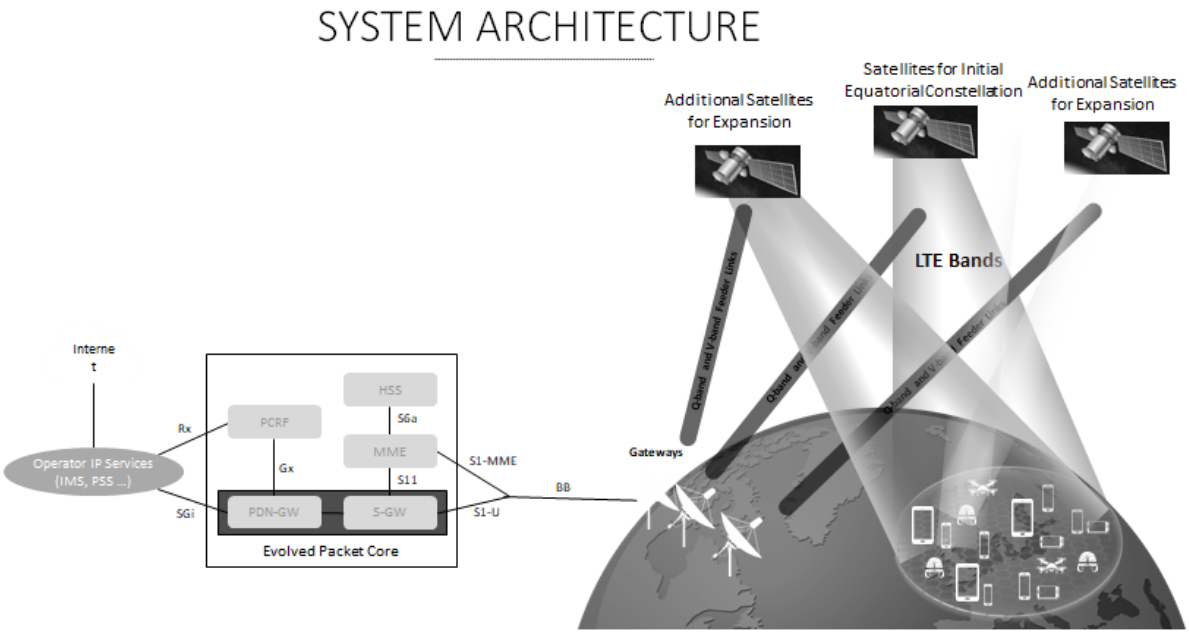

Figure 2: System Architecture

A.5 CESSATION OF EMISSIONS

Pursuant to Section 25.207,[6/] AST will make its space stations capable of ceasing radio emissions by use of ground commands that will ensure definite cessation of emissions. As noted above, AST will have the ability to control the system via locations outside of the United States.

A.6 SPECTRUM SHARING ANALYSIS

The frequency ranges that AST proposes to use in the U.S. for user terminals will be those licensed to mobile service providers partnering with AST. Consequently, unacceptable interference within these frequency bands is not an issue for this application.

The gateway stations will be located in Midland, Texas and other sites to be chosen after the required site coordination is successfully concluded. The use of the frequency band 45.5-47 GHz for gateways, allocated in the U.S. to the MSS in the Earth-to-space direction, is the subject of a separate waiver request, and will be on a non-interference, non-protected basis. The same is true for the frequency band 42-42.5 GHz in the space-to-Earth direction, which is not allocated to satellite services in the United States.

6/ 47 C.F.R. § 25.207.

As to the use of the internationally allocated FSS V band frequencies, AST commits to comply with the regulations adopted at the 2019 World Radio Conference ("WRC-19") concerning the use of the band by NGSO satellite systems, and will participate in the process to ensure that the maximum acceptable levels of interference into GSO networks are not exceeded in accordance with Resolution COM5/10 (WRC-19).

Moreover, transmissions in the bands adjacent to the 50.2-50.4 GHz band also will be tailored so as not to exceed the Resolution 750 (Rev.WRC-19) out-of-band limits adopted for NGSO satellite system earth stations brought into use after the date of entry into force of the Final Acts of WRC-19.

A.7 POWER FLUX DENSITY AT THE EARTH'S SURFACE

Section § 25.208(r) contains PFD limits that apply in the 37.5-40 GHz frequency band.[7/] The PFD limits when no allowance is made for propagation impairments are as follows:

- -132 dB(W/m2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -132 + 0.75 (δ-5) dB(W/m2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -117 dB(W/m2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane,
- and during periods when FSS system raises power to compensate for rain-fade conditions they are:
- -120 dB(W/m2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -120 + 0.75 (δ-5) dB(W/m2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and

7/ 47 C.F.R. § 25.208(r).

- -105 dB(W/m2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Sections § 25.208(s) and (t) also contain PFD limits that apply in the 40-42 GHz frequency band.[8/] The PFD limits when no allowance is made for propagation impairments are as follows:

- -115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + 0.5 (δ-5) dB(W/m2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.
- Moreover, Table 21-4 of the Radio Regulations (RR) contains PFD limits that apply to non-GSO FSS satellite systems in the 42-42.5 GHz frequency band, which are:
- -120 dB(W/m2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -120 + 0.75 (δ-5) dB(W/m2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

The maximum downlink EIRP density that the SpaceMobile can transmit in the frequency band 40-42 GHz is -36.8 dBW/Hz. The worst case PFD will occur for the shortest distance from the satellite to the Earth, 730 km.

Table 1 below shows the corresponding PFD levels on the Earth's surface and the margins with respect to the Part 25 masks applicable to the frequency band 40-42 GHz, assuming the satellite beam can be pointed to a minimum elevation angle of 5°. The margins are always equal to or greater than 0 dB.

8/ 47 C.F.R. § 25.208(s) and (t).

Table 1: Demonstration of Compliance with 47 C.F.R. § 25.208(s) and (t)

Elevation Angle (°)	Range (km)	Spreading Loss (dB)	Pfd (dBW/m^2/MHz)	§25.208 Mask (dBW/m^2/MHz)	Margin (dB)
5	2630.6	139.4	-116.2	-115.0	1.2
10	2219.8	137.9	-114.7	-112.5	2.2
15	1894.6	136.5	-113.3	-110.0	3.3
20	1640.0	135.3	-112.1	-107.5	4.6
25	1441.0	134.2	-110.9	-105.0	5.9
90	730.0	128.3	-105.0	-105.0	0.0

The maximum downlink EIRP density that the SpaceMobile can transmit in the frequency band 37.5-40 GHz under faded conditions and in the band 42-42.5 GHz is -40.6 dBW/Hz.

In unfaded conditions, the maximum EIRP density transmitted by SpaceMobile in the frequency band 37.5-40 GHz will be reduced by 12 dB. The worst case PFD will occur for the shortest distance from the satellite to the Earth, 730 km.

Table 2 below shows the corresponding PFD levels on the Earth's surface and the margins with respect to the Part 25 mask applicable to the 37.5-40 GHz frequency band under faded conditions and the RR Article 21 PFD limits applicable to the frequency band 42-42.5 GHz, assuming the satellite beam can be pointed to a minimum elevation angle of 5°. The margins are always equal to or greater than 0 dB.

Table 2: Demonstration of Compliance with 47 C.F.R. § 25.208(r) and Table 21-4 of the Radio Regulations

Elevation Angle (°)	Range (km)	Spreading Loss (dB)	Pfd (dBW/m^2/MHz)	§25.208/RR Mask (dBW/m^2/MHz)	Margin (dB)
5	2630.6	139.4	-120.0	-120.0	0.0
10	2219.8	137.9	-118.5	-116.25	2.25
15	1894.6	136.5	-117.1	-112.5	4.6

20	1640.0	135.3	-115.9	-108.75	7.15
25	1441.0	134.2	-114.7	-105.0	9.7
90	730.0	128.3	-108.8	-105.0	3.8

Consequently, compliance with the PFD limits in Section 25.208(c) always will be assured.

Finally, there are no variations in antenna gain over the steerable range. And the spacecraft will maintain the constant EIRP spectrum density which is set to ensure compliance to the PFD requirement in the worst case condition.

A.8 CARRIER FREQUENCY OF SPACE STATION TRANSMITTERS

SpaceMobile will comply with 47 C.F.R. § 25.202(e).

A.9 EMISSION LIMITATIONS

SpaceMobile will comply with 47 C.F.R. § 25.202(f)(1), (2) and (3).

A.10 INTERFERENCE ANALYSIS

The AST system has been engineered to co-exist with other systems. With regard to the V band gateway beams, the following attributes will allow AST to successfully share with other users:

- Steerable antennas with narrow beamwidth (no more than 0.75 degrees 3 dB beamwidth) and no performance degradation over the steerable range;
- Low sidelobe levels that minimize the potential interference outside of the antenna main beam;
- The ability to switch traffic from one gateway beam to another one if the first beam experiences interference issues; and
- Any gateway beam can be independently switched off per polarization.

With regard to sharing with terrestrial networks in the V band downlink frequencies, compliance with the FCC rules and Article 21 PFD limits will be sufficient to protect terrestrial services.

In the service links using the LTE frequencies, successful frequency sharing may be accomplished due to:

- Narrow beamwidth beams that can be individually turned off when they near a geographic area where AST has not been provided authorization to use the frequency;
- Low beam sidelobes and fast rolloff because of the use of large aperture phased array antenna;
- Dynamically controlled beam center and beam EIRP level; and
- Adjacent Channel Leakage Ratio ("ACLR") that is minimized and compliance with applicable terrestrial standards with the use of Digital Predistortion ("DPD") on-board and improvements in the large number of beams.

Sharing with other NGSO systems operating in the same bands: Section A.7 above addresses how AST will successfully share with other NGSOs.

Sharing with radio astronomy: AST recognized that the radio astronomy service ("RAS") operates in the 42.5-43.5 GHz band. Adequate filtering will be implemented in the V band gateway transmitters to attenuate the out-of-band emissions that could fall within the RAS band. Additionally, the gateway sites can be selected with adequate geographic separation from the RAS sites which, coupled with the filtering, will protect RAS.

A.11 ITU FILINGS FOR SPACEMOBILE

The SpaceMobile satellite network will operate under network filings made on behalf of AST with the ITU by the Papua New Guinea administration under the name MICRONSAT.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I either prepared or reviewed the engineering information submitted in this application, and that it is complete and accurate to the best of my knowledge and belief.

Huiwen Yao, PhD
Chief Technology Officer
AST&Science
5825 University Research Ct. Suite 2300
College Park, MD 20740
240-650-0054

PAPUA NEW GUINEA
NATIONAL INFORMATION AND COMMUNICATIONS TECHNOLOGY AUTHORITY

NATIONAL INFORMATION AND COMMUNICATIONS TECHNOLOGY ACT 2009
National Information and Communications Technology (Radio Spectrum) Regulation 2010

Radiocommunications Apparatus Licence

Licence Type: Space Station License

Licence No: RCAP-SS-0000-002

Issued by NICTA

The Common Seal of

SCHEDULE 1 – GENERAL PARTICULARS

Date of Issue: 13 November 2018

Date of Expiry: 13 November 2023 (may be extended in accordance with Satellite Filing Agreement 2017)

Name: AST&Science, LLC

Postal Address: 1111 Brickell Ave. Suit 1100, Miami, Florida, USA

SCHEDULE 2 - TECHNICAL CHARACTERISTICS

In accordance with: **Information registered with ITU**

Satellite Name: Blue Walker 1

Orbital Location: 698 km Polar LEO

Station Type: LEO

Service Type: Mobile Satellite

Uplink/ Downlink Frequencies

Uplink Frequencies	Downlink Frequencies	Starting Frequencies Uplink/Downlink	Ending Frequencies Uplink/Downlink
600-900 MHz (LTE Bands up to 900 MHz)	600-900 MHz (LTE Bands up to 900 MHz)	600 MHz (and other LTE Bands)	900 MHz (and other LTE Bands)

SCHEDULE 3 - LICENCE CONDITIONS

This Licence is subject to compliance with:

Condition Number	Condition Description
605	i. the National Information and Communications Technology Act 2009; ii. the National Information and Communications Technology (Radio Spectrum) Regulation 2010; iii. the Satellite Filing Agreement 2017; iv. Provisions of the ITU Radio Regulations

End-of-Life Disposal and Orbital Debris Mitigation Response

In accordance with Section 25.114(d)(14) of the Commission's rules,[1/] AST&Science LLC ("AST") hereby provides a description of the design and operational strategies that it will used to mitigate orbital debris for its low earth orbit ("LEO") non-GEO SpaceMobile satellite constellation. AST takes seriously its duties to provide for orbital debris mitigation and employs staff who are experts in this area. AST has prepared a complete orbital debris mitigation plan, which it fully intends to meet to assure compliance with Commission orbital debris requirements.

AST has assessed and limited the amount of debris that would be released in a planned manner during normal operations. Specifically, the spacecraft have been designed so that they will not provide a source of debris during normal operations in that the spacecraft will not release any components from its primary body. Additionally, the spacecraft itself is not anticipated to become a source of debris at the end of its usable life. Operationally, there is a plan to de-orbit the satellite at the end of life within 2 years to be in compliance with the 25 year decommission requirement in accordance with the IADC Guidelines for Space Debris Mitigation. If the satellite were to fail, the natural gravity gradient stabilized orientation will minimize the ballistic coefficient and the vehicle will naturally decay within 10 years. Conjunction assessments will be performed as an on-going process throughout operation. A third party will provide software to perform the analysis and the conjunction warnings will be provided by the Joint Space Operations Center ("JSpOC") and LeoLabs. The analysis software will assess the probability of collision as it evolves over time in the days preceding the conjunction, and a decision will be made based on the assessment of the collision probability. The spacecraft will contain an on-board electric propulsion system that is required to provide a collision avoidance maneuver within a 24-hour window of an identified probable conjunction event.

AST additionally has assessed and limited the probability of one of its space stations becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. The spacecraft propulsion system will provide AST with the means of conducting post-mission disposal for complete destructive reentry. The

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1/ 47 C.F.R. § 25.114(d)(14).

electric propulsion system operates with Krypton propellant, which is an inert, noble gas, and does not provide any addition means of reaction with other materials. The propulsion system requires between 250-300W of input power for operation with redundant power lines incorporated in the power processing unit ("PPU").

Regarding the probability of accidental explosions during and after completion of mission operations, AST has assessed and limited the probability of such an event occurring. The two sources of on-orbit explosions are propellant tanks and batteries, both of which will be continuously monitored throughout the spacecraft lifetime for failure modes. The batteries are continuously monitored by an electrical power system ("EPS") module to avoid over-charging/discharging. Should battery operation fall outside of an acceptable range it will be discharged and taken out of service, removing any stored energy it contained. All batteries on-board the control satellite will have a 1.5mm aluminum casing and thermally isolated to mitigate thermal loads. Additionally, the batteries will have protective circuitry to regulate safe and nominal voltage and current levels. The propellant for the electric propulsion system is an inert and non-reactive noble gas, and does not present a source of energy conversion in the event of a gas leak. The pressurized propellant tank will be continuously monitored with continuous downlink of state-of-health telemetry. Propellant safety measures include a system of pressure control and relief valves, with complete thermal isolation and temperature control. Any stored energy remaining at the spacecraft's end-of-life will be removed via depletion of the propellant tank and permanently discharging the on-board batteries.

AST also has assessed and limited the probability of the space stations becoming a source of debris by collisions with large debris or other operational space stations. Satellite station-keeping within a given orbital plane is monitored by both a primary and secondary flight operations location, one in Midland, TX and the other in College Park, MD. GPS receivers provide precise satellite locations that will be used to maintain a precision ephemeris for each spacecraft. This ephemeris data will be shared with JSpOC and with other operators with assets flying at the same orbital altitude, and may also be made publicly available. Provided information is made available on new launches that might cross the operational altitude of the AST satellites, these can be monitored, however there is no possibility of action should the

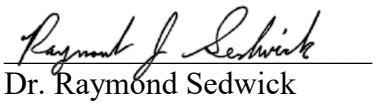
launch vehicle malfunction and cross paths with one of the AST satellites. New spacecraft can be placed in a lower altitude, transfer orbit before reaching the final position. By utilizing the difference in altitude, and thus orbital period, the new spacecraft can be separated in phase from the other spacecraft. Once the proper phase separation is in place, the altitude of the new spacecraft can be raised until it is in its allocated position, separated in phase from the other spacecraft in a similar orbit. Each spacecraft will contain an on-board electric propulsion system that is required to provide a collision avoidance maneuver within a 24-hour window of an identified probable conjunction event. In addition to the redundancies of the propulsion unit discussed previously, the flight computer has both hardware and software redundancy, and magnetic torque rods are distributed across the entire array surface. These torque rods provide full attitude control during deorbit and due to their distributed nature provide 10-20 fold hardware redundancy.

Finally, in terms of the post-mission disposal plans for the space station at end-of-life, including the quantity of propellant that will be reserved for post-mission disposal maneuvers, the primary end of life plan is a powered re-entry. This will use a combination of first orbit lowering using onboard propulsion and then drag control using the spacecraft attitude and orbit control system ("AOCS"). Specifically, the on-board electric propulsion system will provide the means of de-orbiting the spacecraft to an altitude at which the maximum spacecraft drag exceeds the propulsive capability. The array can be pitched to the maximum drag orientation and then yawed around nadir to throttle the drag and control the deorbit rate. Within three days of re-entry, where the atmospheric density is more predictable, this can be used to vary the re-entry longitude to control the re-entry location. At maximum ballistic coefficient (edge on), the de-orbit process can be momentarily halted, extending the re-entry from 3 days to 200 days, and allowing for a re-phased descent. Sufficient propellant will be maintained throughout the mission in order to provide the deorbit maneuver at end-of-life. This maneuver, in accordance with NASA standard NASA-STD-8719.14B for all debris mitigation practices, shall lower the altitude to approximately 400 km, at which point the array can be pitched with magnet torquers that can control the exposed surface array, effectively throttling the drag. This drag force is larger than the deorbit thrust provided by the electric propulsion system and provides more controllable descent below 400 km. Prior to the drag assisted deorbit, complete depletion of the electric

propulsion propellant reservoir will occur before destructive reentry. In the event the AOCS system fails, a casualty risk assessment using the NASA Debris Assessment Software indicates a total risk assessment of 1:19,700, which is lower than the 1:10,000 requirement. Of the debris that does not demise before reaching the surface, those substantially contributing to the total casualty area are well below the 15 Joule kinetic energy requirement. Those components above the 15 Joule requirement contribute a total debris casualty area characterized by the 1:19,700 casualty risk assessment.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I either prepared or reviewed the engineering information submitted in this application, and that it is complete and accurate to the best of my knowledge and belief.



Dr. Raymond Sedwick
Chief Scientist, Space and Formation Flight
AST&Science LLC
Midland International Air & Space Port
2901 Enterprise Lane
Midland, TX 79706
1.432.276.3966