Before the
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Petition to Modify Parts 2 and 101 of the Commission's Rules to Enable Timely Deployment of Fixed Stratospheric-Based Communications Services in the 21.5-23.6, 25.25-27.5, 71-76, and 81-86 GHz Bands	)	RM-________

PETITION FOR RULEMAKING

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SUMMARY

Elefante Group, Inc. ("Elefante Group") asks the Commission to commence a rulemaking to modify Parts 2 and 101 of the Commission's rules, and such other rule Parts as may be necessary, to enable the deployment of Stratospheric-Based Communications Services ("SBCS") in this country. As explained herein, SBCS is a transformative new service based on advanced, cutting edge technologies. Through this Petition, the Commission is offered the opportunity to enable U.S. leadership in both 5G deployment and technological innovation in the form of commercial stratospheric communications platforms and services.

The deployment of SBCS as envisioned by Elefante Group, working with Lockheed Martin Corporation ("Lockheed Martin") on the technologies, leverages both government investment and substantial commitment of private capital to deliver low latency, high-capacity communications efficiently and at less cost – as much as 80% less or more – by overcoming infrastructure challenges that typically confront ground-based deployments. Elefante Group's SBCS, by offering network-in-the sky capabilities to a significant service area – >15,000 km^2 – each time, and as soon as an Elefante Group SBCS solution is deployed, will complement other communications delivery systems in critical ways to accelerate 5G deployment. As such, SBCS will be an essential element if the United States is to win the race to 5G. At the same time, SBCS will help advance numerous other Commission objectives.

In this Petition, Elefante Group proposes a new model of spectrum access in which SBCS systems will exhibit compatibility by design. These features, made possible in large part because of the unique "geometry" of SBCS deployments relative to other incumbent users, combined with appropriate technical and operational regulations, as proposed herein, will support maximized utilization of encumbered bands in a way that permits future growth of all users. This deliberate adoption of compatibility by design drives the spectrum to which Elefante Group

proposes that the Commission provide SBCS co-primary access as a Fixed Service under Parts 2 and 101 of the Rules: 21.5-23.6 GHz, 25.25-27.5 GHz, 71-76 GHz, and 81-86 GHz. As a result of considerable review of candidate spectrum bands for SBCS, taking into account numerous factors, consideration of existing uses of the bands, and following numerous compatibility studies conducted by Lockheed Martin, appended hereto, Elefante Group respectfully submits that the Commission's enabling SBCS to access these bands as proposed herein constitutes the best prospect for enabling advanced SBCS systems in this country to become reality and help win the race to 5G.

Elefante Group airship-based radio stations, generically referred to as stratospheric platform stations ("STRAPS"), will operate at nominally fixed locations at approximately 65,000 ft. altitude (less than 20 km) and support high-capacity SBCS – 1 Tbps in both directions between the STRAPS and fixed user terminals ("UTs") – and Internet of Things ("IoT") - enabling solutions. These communications solutions – including 4G and 5G backhaul (enabling both buildout in rural areas and "urban deserts" and densification in well served urban areas), enterprise Wide Area Network ("WAN"), and residential broadband services – and applications benefit residents and small businesses as well as the communications, government, enterprise, and institutional sectors. As described herein, each Elefante Group airship will be capable of delivering network capabilities over a 70 km radius and a platform coverage area of 15,400 km^2 (6,000 mi^2) on day one of deployment, bypassing the many infrastructure problems that plague and delay ground-based buildouts, sometimes for years after they start. For this reason, using 5G-compatible technologies, timely deployment of Elefante Group's SBCS systems beginning in the next four years will accelerate 5G deployment in this country, as well as service numerous other national objectives, including bridging the digital divide in both rural areas and "urban

deserts," supporting the maintenance and restoration of communications during and following natural disasters, and creating thousands of American jobs.

Notably, Elefante Group proposes to do all of this in already encumbered spectrum without putting constraints on the existing operations of incumbents or undermining the growth and evolution of co-primary incumbent services – while permitting the deployment of competitive SBCS in the same spectrum serving the same markets. To achieve this, following many months of analysis, including numerous compatibility studies – 20 of which are appended to the Petition – and considering numerous technical and service factors, Elefante Group and Lockheed Martin evaluated the 17-43.5 GHz spectrum range and have identified 21.5-23.6 GHz (uplinks) and 25.25-27.5 GHz (downlinks) as the best spectrum in which SBCS-UT links can be deployed in the United States and deliver its expected benefits.

Elefante Group also proposes that SBCS have access to the 71-76 and 81-86 GHz bands for feeder links. Only a limited number of feeder links are required for the Elefante Group SBCS system, since its airship platforms will have "network in the sky" capability including beam-to-beam switching and flexible capacity allocation capability. Elefante Group respectfully submits that, if the opportunity is taken to make these bands accessible to SBCS on a non-exclusive basis, the opportunity for meaningful deployment of SBCS and the delivery of those benefits to the United States will be secured, making American lives better, communities safer, and the country more prosperous.

Elefante Group asks the Commission to adopt

- a co-primary non-Federal Fixed Services allocation in the 25.25-27.5 GHz band to complement the existing Fixed Service allocations in the other bands identified above,
- SBCS technical and operational rules applicable to STRAPS and UTs operating in the 21.5-23.6 and 25.25-27.5 GHz bands (the "22-23 GHz Band" and the "26

GHz Band," respectively) and impose coordination obligations on SBCS that will ensure compatible operations with incumbents in those bands,

- rules enabling the use of the 71-76 and 81-86 GHz bands (the "70/80 GHz Bands") for SBCS feeder links, and
- licensing rules for non-exclusive assignments to SBCS operators to the 22-23 and 26 GHz Bands on a Regional Economic Area ("REA") basis while requiring registration of STRAPS and STRAPS-UT links that SBCS operators deploy.

In addition, Elefante Group submits that this Petition, and the rulemaking which follows, qualify for treatment under Section 7 of the Communications Act of 1934, as amended. Specifically, as soon as practicable and no later than one year after the filing of this Petition, the Commission should institute a rulemaking to implement an SBCS regulatory framework and complete that rulemaking no later than one year later, i.e., before May 31, 2020. SBCS represents both a set of novel services relying on new technologies, is technically feasible and commercially viable, and is clearly in the public interest.

The remainder of this Petition is organized as follows.

In Section II, Elefante Group describes the technological breakthroughs in both airship platforms and communications systems that make SBCS deployment an achievable reality in the next few years.

In Section III, the Petition describes the physical components of the SBCS system that Elefante Group plans to deploy – both the airship and the ground operations network.

Section IV provides an overview of the communications product markets that Elefante Group intends to serve. Further, that section explains how SBCS deployments, such as the one Elefante Group is planning, will help achieve a variety of important Commission objectives including major investment in next generation communications infrastructure in both rural areas and "urban deserts," bridging the Digital Divide, enabling 4G, 5G, and IoT densification, maximizing spectrum use and efficiency, assisting in maintaining communications during natural

disasters as well as helping ensure that lost communications capabilities may be restored quickly, and, lastly, creating American jobs.

Elefante Group explains in Section V the operational benefits of SBCS systems that complement other communications delivery systems that make SBCS critical to enabling an accelerated deployment and reach of next generation networks in this country.

Section VI reviews the spectrum needed to achieve 1 Tbps capacity up and down between STRAPS and UTs by the SBCS system designed by Elefante Group.

Elefante Group describes in Section VII the process by which it identified the specific spectrum bands proposed in this Petition in which to implement SBCS, including the many spectrum compatibility analyses that Lockheed Martin has conducted on its behalf concerning incumbent operations in the bands. (The compatibility analyses are detailed in the Appendices to the Petition.)

In Section VIII, Elefante Group discusses its planned use of the 70/80 GHz Bands for SBCS feeder links, including current allocations in the band for Fixed Services and compatibility considerations.

In Section IX, Elefante Group describes the proposed regulatory framework for SBCS, including technical and operational rules and limits, as well as the licensing and registration regime Elefante Group proposes.

Finally, in Section X, Elefante Group demonstrates that this Petition qualifies for expedited Section 7 treatment under the Communications Act. SBCS is a new technology and service for which there is not a full regulatory framework in place, Elefante Group's SBCS system is technically and economically feasible, and grant of this Petition for Rulemaking would be in the public interest. Indeed, the Commission should institute a rulemaking to consider

SBCS rules within twelve months, and should adopt SBCS rules within twelve months after that, by the end of May, 2020.

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PETITION FOR RULEMAKING

Elefante Group, Inc. ("Elefante Group"), pursuant to Section 1.401 of the Commission's Rules, 47 C.F.R. § 1.401, hereby asks the Commission to commence a rulemaking to modify Parts 2 and 101 of the Commission's rules, and such other rule Parts as may be necessary, to enable the deployment of Stratospheric-Based Communications Services ("SBCS") in this country. As explained herein, SBCS is a transformative new service based on advanced, cutting edge technologies. Through this Petition, the Commission is offered the opportunity to enable U.S. leadership in both 5G deployment and technological innovation in the form of commercial stratospheric communications platforms and services.

The deployment of SBCS as envisioned by Elefante Group, working with Lockheed Martin Corporation ("Lockheed Martin") on the technologies, leverages both government investment and substantial commitment of private capital to deliver low latency, high-capacity communications efficiently and at less cost – as much as 80% less or more – by overcoming infrastructure challenges that typically confront ground-based deployments. Elefante Group's SBCS, by offering network-in-the sky capabilities to a significant service area – >15,000 km^2 – each time, and as soon as an Elefante Group SBCS solution is deployed, will complement other communications delivery systems in critical ways to accelerate 5G deployment. As such, SBCS

will be an essential element if the United States is to win the race to 5G. At the same time, SBCS will help advance numerous other Commission objectives.

In this Petition, Elefante Group proposes a new model of spectrum access in which SBCS systems will exhibit compatibility by design. These features, made possible in large part because of the unique "geometry" of SBCS deployments relative to other incumbent users, combined with appropriate technical and operational regulations, as proposed herein, will support maximized utilization of encumbered bands in a way that permits future growth of all users. This deliberate adoption of compatibility by design drives the spectrum which Elefante Group proposes that the Commission provide SBCS co-primary access to as a Fixed Service under Parts 2 and 101 of the Rules: 21.5-23.6 GHz, 25.25-27.5 GHz, 71-76 GHz, and 81-86 GHz. As a result of considerable review of candidate spectrum bands for SBCS, taking into account numerous factors, consideration of existing uses of the bands, and following numerous compatibility studies conducted by Lockheed Martin, appended hereto, Elefante Group respectfully submits that the Commission's enabling SBCS to access these bands as proposed herein constitutes the best prospect for enabling advanced SBCS systems in this country to become reality and help win the race to 5G.

I. OVERVIEW AND SUMMARY

Elefante Group, a United States corporation founded in 2015 and headquartered in Denver, Colorado, aspires to be the world leader in persistent, low latency stratospheric-based communications, sensing, and infrastructure. After collaborating with Lockheed Martin for over two and a half years and leveraging Lockheed Martin's many decades of expertise with lighter-than-air ("LTA") platforms, sensing and communications systems, Elefante Group is ready to build, test, and, beginning in 2022, deploy commercial stratospheric radio communications solutions that will serve both urban and rural areas.

Elefante Group airship-based radio stations, generically referred to as stratospheric platform stations ("STRAPS"),[1] will operate at nominally fixed locations at approximately 65,000 ft. altitude (less than 20 km) and support high-capacity SBCS – 1 Tbps in both directions between the STRAPS and fixed user terminals ("UTs") – and Internet of Things ("IoT") - enabling solutions. These communications solutions – including 4G and 5G backhaul (enabling both buildout in rural areas and "urban deserts" and densification in well served urban areas), enterprise Wide Area Network ("WAN"), and residential broadband services – and applications benefit residents and small businesses as well as the communications, government, enterprise, and institutional sectors. As described herein, each Elefante Group airship will be capable of delivering network capabilities over a 70 km radius and a platform coverage area of 15,400 km^2 (6,000 mi^2) on day one of deployment, bypassing the many infrastructure problems that plague and delay ground-based buildouts, sometimes for years after they start. For this reason, using 5G-compatible technologies, timely deployment of Elefante Group's SBCS systems beginning in the next four years will accelerate 5G deployment in this country, as well as service numerous other national objectives, including bridging the digital divide in both rural areas and "urban deserts," supporting the maintenance and restoration of communications during and following natural disasters, and creating thousands of American jobs.

Notably, Elefante Group proposes to do all of this in already encumbered spectrum without putting constraints on the existing operations of incumbents or undermining the growth and evolution of co-primary incumbent services – while permitting the deployment of competitive SBCS in the same spectrum serving the same markets. To achieve this, following

[1] Elefante Group uses the term STRAPS to apply to any stratospheric airborne platform radio station deployed by an SBCS operator, which could include not just LTA deployments but, for example, stations on fixed-wing platforms as well.

many months of analysis, including numerous compatibility studies – 20 of which are appended to the Petition – and considering numerous technical and service factors, Elefante Group and Lockheed Martin evaluated the 17-43.5 GHz spectrum range and have identified 21.5-23.6 GHz (uplinks) and 25.25-27.5 GHz (downlinks) as the best spectrum in which SBCS-UT links can be deployed in the United States and deliver its expected benefits.

Elefante Group also proposes that SBCS have access to the 71-76 and 81-86 GHz bands for feeder links. Only a limited number of feeder links are required for the Elefante Group SBCS system, since its airship platforms will have "network in the sky" capability including beam-to-beam switching and flexible capacity allocation capability. Elefante Group respectfully submits that, if the opportunity is taken to make these bands accessible to SBCS on a non-exclusive basis, the opportunity for meaningful deployment of SBCS and the delivery of those benefits to the United States will be secured, making American lives better, communities safer, and the country more prosperous.

Elefante Group asks the Commission to adopt

- a co-primary non-Federal Fixed Services allocation in the 25.25-27.5 GHz band to complement the existing Fixed Service allocations in the other bands identified above,
- SBCS technical and operational rules applicable to STRAPS and UTs operating in the 21.5-23.6 and 25.25-27.5 GHz bands (the "22-23 GHz Band" and the "26 GHz Band," respectively) and impose coordination obligations on SBCS that will ensure compatible operations with incumbents in those bands,
- rules enabling the use of the 71-76 and 81-86 GHz bands (the "70/80 GHz Bands") for SBCS feeder links, and
- licensing rules for non-exclusive assignments to SBCS operators to the 22-23 and 26 GHz Bands on a Regional Economic Area ("REA") basis while requiring registration of STRAPS and STRAPS-UT links that SBCS operators deploy.

In addition, Elefante Group submits that this petition, and the rulemaking which follows, qualify for treatment under Section 7 of the Communications Act of 1934, as amended (the "Act"), 47 U.S.C. §157. Specifically, as soon as practicable and no later than one year after the

filing of this Petition, the Commission should institute a rulemaking to implement an SBCS regulatory framework and complete that rulemaking no later than one year later, i.e., before May 31, 2020. SBCS represents both a set of novel services relying on new technologies, is technically feasible and commercially viable, and is clearly in the public interest.

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Elefante Group explains in Section V the operational benefits of SCS systems that complement other communications delivery systems makes SBCS critical to enabling an accelerated deployment and reach of next generation networks in this country.

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II. STRATOSPHERIC-BASED COMMUNICATIONS, AN IDEA WHOSE TIME HAS COME IN TIME TO WIN THE RACE TO 5G

While the concept of stratospheric-based communications has been circulating for several decades, deploying stratospheric platforms and communications payloads as a commercially practical reality has required certain technological advances that have not been available until recently. Elefante Group is partnering with Lockheed Martin on technology to leverage recent

breakthroughs in multiple areas of LTA platform capabilities and the communications technologies to design, develop, build and deploy SBCS by 2021. Lockheed Martin is the world leader in LTA technologies with an over 100-year history in producing LTA systems through its acquisition of Goodyear Aerospace (by way of Lockheed Martin's acquisition of Loral Corporation in 1997).[2]

In the past 15 years, Lockheed Martin has led the development of two stratospheric airship programs – High Altitude Airship ("HAA") and Integrated Structure is Sensor ("ISIS")[3] -- for U.S. Government agencies.[4] The two programs and Lockheed Martin's continuing

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2 Lockheed Martin has an unparalleled airship legacy that traces its LTA origins to 1911 with the development of manned and unmanned aerostats for the military. In 1923, the Goodyear Zeppelin Corporation was chartered – and with its subsequent companies Goodyear Aircraft, Goodyear Aerospace, Loral, and now Lockheed Martin – became the world's most prolific supplier of airships and balloons. This vast experience has continued from the rigid airships Akron and Macon through the hundreds of convoy escort airships of World War II and the large, radar-bearing early-warning Navy non-rigid airships of the 1950s and 1960s, through the design and Federal Aviation Administration ("FAA") certification of advertising airships for Goodyear, and the design, production, operation and support of the United States Air Force ("USAF") Tethered Aerostat Radar System ("TARS") and the Persistent Threat Detection System ("PTDS") aerostats for the military.

3 ISIS was a joint Defense Advanced Research Projects Agency ("DARPA") and Air Force Science and Technology ("S&T") program to develop and integrate an advanced radar into a high-altitude airship. The program consisted of three phases: Concept Development, Technology Development, and Demonstration. The Concept Development and Technology Development phases were completed by 2008 and the airship portion of the Demonstration program began in 2009 and essentially ended in 2012 so that the program could focus on the radar payload which needed additional development.

The program resulted in a completed airship system design that included subcomponent details and, in many cases, completed prototypes. New and advanced analysis and modeling tools were developed to predict and optimize performance, and flight control protocols were developed and tested in a Systems Integration Lab ("SIL"). An advanced high energy density regenerative solar array and hydrogen/oxygen fuel cell power system was demonstrated on a small scale and the full system evolved through final stages. A high-power surge fuel cell power system was also demonstrated. Elefante Group plans to use the solar array, power control electronics and some of the fuel cell efforts in the unmanned STRAPS design. The development of the ISIS airship was delayed to focus on radar risk reduction, and the program was then ended in 2015.

4 The HAA program, which commenced in 2002, morphed into the High Altitude Long Endurance – Demonstration ("HALE-D") which demonstrated important functions necessary for any STRAPS deployment and expanded Lockheed Martin's expertise necessary to realizing the current program. During the HAA-HALE-D program, Lockheed Martin developed key

independent research and development ("IRAD") investments, along with significant investment by Elefante Group, in airship design, envelope materials and power subsystems have resulted in technology development that Elefante Group's SBCS systems will draw upon for success.

Indeed, there have been several enabling technological breakthroughs in roughly the last decade that will allow Elefante Group, working with Lockheed Martin on the technologies, to make STRAPS-based communications technically achievable and economically viable. These include (1) technologies and analysis capabilities for the platform itself, i.e., an LTA airship in the case of Elefante Group; (2) flight operations capabilities; and (3) the communications network, including the flight payload package. What is missing – and what is the subject of this Petition – is the ability for SBCS systems to access sufficient and appropriate spectrum to provide 1 Tbps of bidirectional capacity.

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technologies (power, materials, propulsion, and pressurization), and performed the analytical modeling, engineering, and design of an HAA Prototype System through a contract design review-level of maturity. As government priorities shifted and oversight was transferred to the U.S. Army Space and Missile Defense Command ("SMDC")/Army Forces Strategic Command ("ARSTRAT"), Lockheed Martin applied these capabilities and technology advancements in the modified HAA Phase 3 program, in which the company designed, built, and flight-tested the sub-scale proof-of-concept HALE-D system. The HALE-D had all the elements of the archetypical high altitude UAS including a solar regenerative power system, high-strength flexible laminate construction, electric propulsion, a Vehicle Management System with some autonomous functions, and both line of sight ("LOS") and beyond line of sight ("BLOS") command and control ("C2") communications with its ground stations.

The program involved extensive coordination with the FAA and received its airworthiness approval from the Army's Aviation Applied Technology Directorate ("AATD"). After the Certificate of Authorization for flight was received on July 20, 2011 from the FAA, the airship was flight tested on July 27, 2011. The airship reached 32,637 feet altitude, where the flight was terminated after an issue with the pressurization system prevented continued ascent and the airship approached the bounds of the FAA-approved operational area. Termination proceeded exactly in accordance with the planned contingency procedure. While HALE-D did not reach mission altitude, the HALE-D flight demonstrated that, in coordination with the necessary government entities, Lockheed Martin had the expertise to integrate a large LTA UAS system into the National Airspace System ("NAS") and operate safely even during a contingency.

In the process of designing both the HAA prototype and HALE-D, Lockheed Martin developed materials, analysis techniques, and high-altitude designs that are directly applicable to the Elefante SBCS project. The residual deep experience gained on these programs will enable the rapid development and deployment of the Elefante SBCS system.

A. Improvements in Regenerative Power Systems and Hull Materials for Helium Retention Have Made Persistent Stratospheric LTA Platforms Achievable

In the programs discussed above, technologies have been developed that benefited from previous federal government and Lockheed Martin investment, and nearly 30 months of funding by Elefante Group. Critical elements for persistent SBCS success that Lockheed Martin has developed, deployed, and tested include fabric development, hull designs, power systems, propulsion, vehicle management, ground systems, and payload and ground communications systems.

For example, Lockheed Martin improvements in hull materials are critical to the readiness of Elefante Group to build its STRAPS. Lockheed Martin has been at the forefront of the development and refinement of suitable structures (including improvements in hull materials, construction, and coatings) that now provide strength, durability, and helium retention capability to build large unmanned airships capable of carrying the requisite payloads for high-capacity, high-performance SBCS, to stay aloft for long durations (six months and more), as well as to extend platform lifetime (for up to a decade or longer), representing multiple firsts of their kind achievements in near-space technologies.[5]

For a STRAPS to be a viable communications platform on a persistent basis, it must not only be large enough to carry the payload, it must also be able to station-keep over the desired coverage area so the communications package can provide a highly reliable service. To do so, the platform must create enough power to drive propulsion systems to maintain position against

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[5] Like ISIS and HAA/HALE-D, a low-drag shaped hull and the four inflated fins arranged in an "X" orientation will make up the Elefante Group STRAPS airframe assembly. The hull and fins are pressure-stabilized structures constructed of fabric laminates containing high-tenacity fibers for strength, adhesives, films as primary helium barriers, and protective outer layers. Subsystem components are attached to the exterior of the hull.

the variable winds at 65,000 ft. Recent advances in energy generation and storage, and efficient propulsion mechanisms make this possible. Power subsystem technologies from Lockheed Martin Space were developed based on decades-long experience in the design of highly reliable power subsystems for space systems.[6] Specifically, advances in solar cells, battery storage, and fuel cells will provide sufficient power 24 hours per day during a six or more month mission for airships to maintain position.[7] Station-keeping around the intended operating location is also enhanced by the maneuverability provided by the four ruddervators attached to the fixed fins. The foregoing features will enable the Elefante Group airships to maintain station within a small radius and nominally fixed location in the stratosphere.

Other improvements will facilitate proper thermal management and enhance the ascent and descent capabilities of Elefante Group's LTA deployed platforms. In total, the improvements in power systems, propulsion, hull materials, airship design and other technological advances enable larger payloads and payload power over what was possible even in the relatively recent past make the planned Elefante Group STRAPS achievable.

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6 The solar-regenerative power subsystem of the airship is designed to collect and store sufficient solar energy to power the airship throughout the day-night (diurnal) cycle for the average weather encountered at altitude based on decades of data analyzed by Lockheed Martin. For the occasional weather systems where propulsion power demands exceed the capability of the regenerative power system, a consumable power system ("CPS") will be available to supplement the regenerative system. The combination of a regenerative power system and a CPS enables the airship to maintain station for the duration of the mission through transient high wind events.

7 Included in the external components of the Elefante Group airships will be the power subsystem, which consists of a solar array for both daytime operation and battery charging, a rechargeable battery that provides power for night operation, and control electronics. The propulsion subsystem is mounted at the tail of the airship, which improves propeller efficiency and therefore improves mission station-keeping. Hull rigidity is maintained by internal pressure, which is maintained by the blowers and valves of the pressurization subsystem. The payload and Vehicle Management System ("VMS") equipment are installed in externally-mounted bays that moderate the extreme high-altitude environment. Elefante Group and Lockheed Martin are monitoring and will continue to monitor, test and incorporate improvements in many commercially available technologies including solar and battery cells.

B. Advances in Communications Technologies Have Made LTA SBCS Achievable

Recent advances in communications technologies that can be deployed at relatively low size, weight and power ("SWaP") enable significant increases in communications capacity possible on LTA platforms. Deploying reliable state-of-the-art communications on stratospheric platforms has required other improvements which Lockheed Martin is contributing, including the ability to generate sufficient capacity over the platform's footprint and the ability to operate compatibly with incumbents in shared spectrum to make the business case for building and launching STRAPS for communications. Lockheed Martin is the developer of the Department of Defense's ("DoD's") most advanced and critical communications systems – the Advanced Extremely High Frequency ("AEHF"), Milstar, and Mobile User Objective System ("MUOS") communications systems. The experience gained with these efforts have formed the basis for development of Elefante Group's communications systems to be deployed on the STRAPS and in UTs and gateway stations.

Specifically, novel antenna designs and construction techniques have improved coverage while minimizing interference. Proprietary advances, created by Lockheed Martin's prior research efforts and under collaboration with and investment by Elefante Group, in payload elements such as frequency converters, fast switches, and amplifiers provide scalable, any beam-to-any beam switching capabilities at low SWaP are also critical contributors to making Elefante Group's SBCS possible. In other words, the payload on a single LTA platform will be able to bring together a full suite of functions to bring network capabilities to the service area independently of ground systems. The ability to reduce SWaP while improving coverage results in greater payload communications capacity and efficiency (for given SWaP) than previously

possible. The enhanced communication STRAPS capabilities ensure that SBCS as envisioned by Elefante Group is technically feasible and economically viable.

III. BASICS OF THE ELEFANTE GROUP AIRSHIP PLATFORM, PAYLOAD, AND GROUND RADIO NETWORK ECOSYSTEM

A. Description of Elefante Group's STRAPS As Well As Envisioned Platform/Fleet and Ground Segment Design

1. STRAPS Design and Technical and Operational Parameters

Operational Height at Station. The Elefante Group airborne platforms are being designed for extended (six months or more) uninterrupted operation at altitudes of approximately 65,000 feet or less over a designated location. This could be easily achieved with an airship when winds are very low, since Elefante Group STRAPS can maintain a very low groundspeed allowing operation in a relatively stationary position (*i.e.*, a few hundreds of meters turning radius) for most of the time. Higher winds require a larger radius for station keeping. To achieve this with a minimum airship size and smallest power system (both size and power are key cost drivers) the operational altitude is a tradeoff between where the air density is high to enhance buoyant lift and the energy required to counter prevailing winds at that altitude is low. Based on analysis of decades of wind records, this occurs between 60,000 to 65,000 feet altitude in most latitudes over CONUS.[8] Average windspeed increases at operating altitudes over 65,000 ft. and any increase of airship speed to counter these winds would require more airship power. For instance, an

8 At the design altitude of 65,000 ft., the Elefante airship is at its pressure height, which means that the helium in the cells has expanded to fill the entire airship hull (no air remaining in the hull), and is at equilibrium, which means that the airship requires only propulsive power necessary to counter the predominantly low-winds at altitude and not to constantly generate dynamic lift as in a fixed-wing aircraft. In other words, the buoyancy of the airship exactly equals the weight of the airship. In this condition, variations in helium temperature caused by the environment (solar radiation, convection, etc.) only affect gas pressure and not airship altitude, as in the case of high altitude balloons. Therefore, the airship remains at a relatively stable altitude that varies only slightly with atmospheric density fluctuations and occasional commanded deviations from this "float" altitude.

airship needs 8 times the power to go from 30 knots to 60 knots. More power represents more mass, requiring a larger airship.

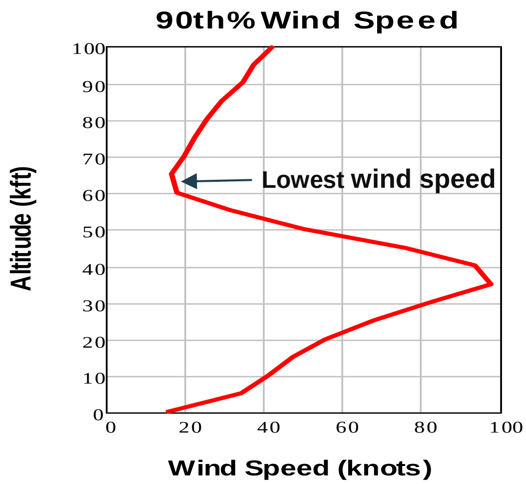


Figure 1 Typical year-round wind speed profile in the Northern Hemisphere

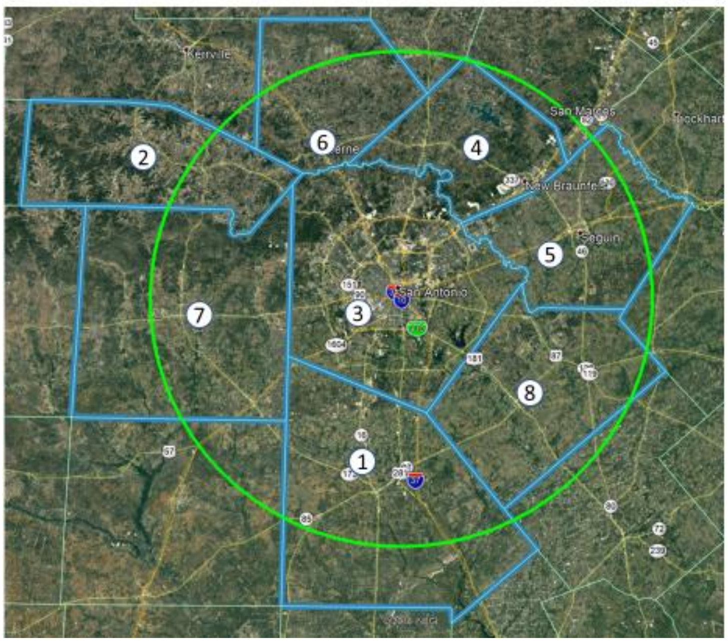
Coverage Area. From 19.8 km (65,000 ft.) altitude, the coverage area of STRAPS with the Elefante Group communications payload will be 70 km radius, which ensures an elevation angle for STRAPS-UT links of 15 degrees at the edge of the coverage area and higher within it. This, as described below, greatly enhances spectrum compatibility with other users. This coverage area equates to 15,400 km^2. Consequently, in most cases, a STRAPS as designed by Elefante Group will be able to serve UTs throughout an entire metro area as well as surrounding rural areas within the platform footprint on day one of deployment at station. In many places within the United States, population density drops rapidly from the metro core to adjacent rural areas. For example, a single STRAPS positioned over Washington, DC would cover the District, surrounding suburb and cities along the Beltway, and extend into many rural communities,[9]

[9] Washington Dulles Airport is only approximately half the coverage radius from the White House.

potentially providing services to the District, all or part of 22 counties in three states, parts of Baltimore, and other independent cities.

Another example is the City of San Antonio, Texas the seventh largest city in the United States with a population of 1.5 million, which has a or population density of 3,242 people per square mile. If you consider the area within the beltway around San Antonio as Urban, then ninety percent of the airship coverage will service all or part of the surrounding seven counties, with population density ranges from 28 to 251 people per square mile.

San Antonio TX Area



County	Map Index	2017 Population	Pops / sq mi
Atascosa	1	48,981	40
Bandera	2	22,351	28
Bexar	3	1,958,578	1,571
Comal	4	141,009	251
Guadalupe	5	159,659	225
Kendall	6	44,026	67
Medina	7	50,066	38
Wilson	8	49,304	61

Population data from US Census 2017 estimates
Mapping from Google Earth Pro

Figure 2

In a few large metro areas (geography wise), such as the Los Angeles basin, more than one STRAPS may be required. As shown in the following compatibility studies, STRAPS coverage areas may overlap without interference to provide seamless coverage over a large metro area.

Airship Size. Specifically, the Elefante Group airship will have a hull volume of more than nine million cubic feet and carry a payload greater than 1000 kilograms. This capacity will be sufficient to support communications, remote sensing, or other defined payloads either singularly or in combination depending upon the particular mission application.

Mission Length. The airships will be designed to operate at altitude for approximately 6 or more months and Elefante Group and Lockheed Martin will work toward mission life of one year or more. At the end of the mission period, a second airship will seamlessly assume operations at the given fixed location following a handover process between the STRAPS that will avoid interruption of services.[10]

2. Ground System Elements Supporting the STRAPS

Elefante Group will have the experience necessary for fleet operations to support SBCS, strengthened through its relationship with Lockheed Martin. There are three types of operational centers needed to support the operation of the Elefante Group fleet of LTA platforms.

Airdocks. The first operational centers are dedicated airdocks for airship construction and maintenance. This is where these large and unique airships will be constructed as well as maintained throughout their operational life. The air docks will also have the customized systems and capability to launch and retrieve airships.

Flight Operations Centers ("FOCs"). FOCs are the second type of center and will coordinate fleet operations and deployments in their region.[11] This includes tracking and

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10 As discussed later, this handover process will require access to at least one additional communications channel in both directions.

11 While Elefante Group intends to launch commercial operations first in the United States, provided it can get access to suitable and sufficient spectrum in a timely fashion, it plans to offer SBCS in a number of other countries, and is already in discussions with several to do so.

planning for transit and station keeping using platform flight data, weather considerations, and coordination with airspace regulations and the FAA.[12]

Network Operating Centers ("NOCs"). The third type of center are NOCs that control the communication payload and support networks. Each NOC will be interconnected with several FOCs. The NOCs will also coordinate, as needed, with other users of the spectrum. Each FOC and NOC will be capable of multiple airship and payload operations along with backup capability for other FOCs and NOCs in case of an outage. Both FOCs and NOCs will be in constant communication, and will jointly coordinate the handover of RF communications from one airship to another.[13] The FOC will support continuous coordinated command and control ("C2") operations by addressing the maneuvers necessary by the current STRAP and the replacement STRAP to facilitate the beam-to-beam service handover which will be controlled by the NOC.

B. Elefante Group System Communications Architecture

The basic communications paths that will support the provision of SBCS planned by Elefante Group are links between STRAPS and UTs, user links, feeder links between STRAPS and gateway terminals, command and control links, and cross links. *See* Figure 3.

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[12] After two years with a production rate of 24 airships a year, the initial fleet is estimated to consist of 48 platforms. An additional 12 platforms will be on standby to replace operational platforms nearing maximum flight time or when the consumable fuel is nearing depletion.

[13] This occurs at the end of an airship's mission and will require two airships to be flown in close proximity to each other.

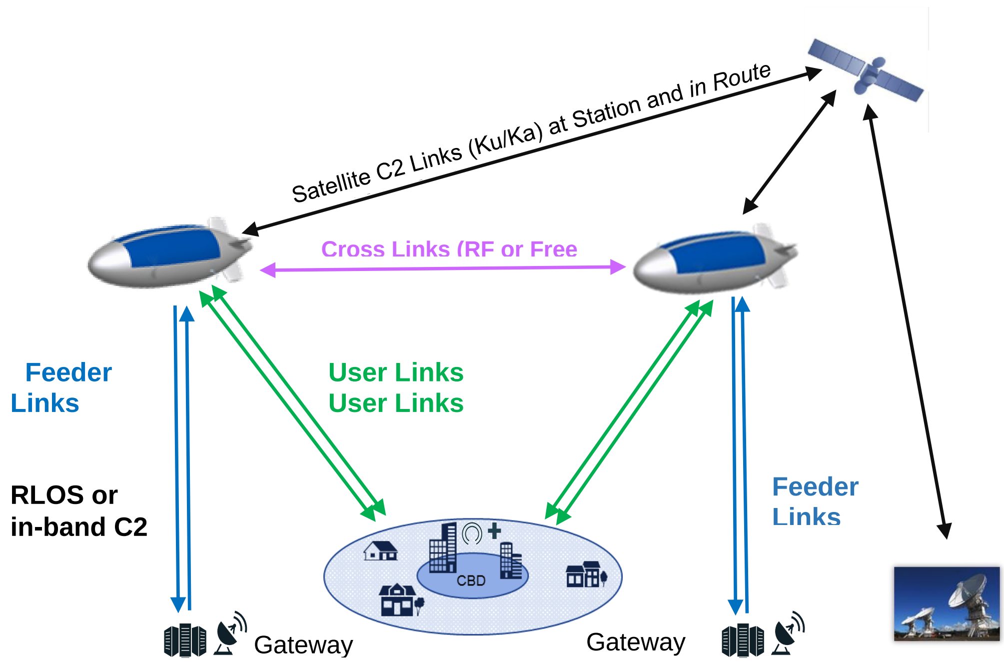

Figure 3. Elefante Group SBCS Communications Architecture

1. User Links between STRAPS and UTs

Deployment of a STRAPS make possible coverage across the entire platform footprint, over 15,000 square kilometers with effectively no coverage gaps. Elefante Group plans to reuse Ka-band spectrum over 540 beams within the STRAPS footprint, each with a 450 MHz channel bandwidth with a customized waveform to provide very high spectral efficiency. Elefante Group anticipates residential and small business end users will utilize UTs that have smaller bandwidths than that used for enterprise customers. Consumer and small business UTs will utilize a sub-channel size of 5-25 MHz. On the other hand, Elefante Group customers could use larger bandwidth, up to 450 MHz, for enterprise and backhaul users, as an example. All UTs within Elefante Group's SBCS system will be professionally installed and maintained, which is a key element to ensuring spectrum compatibility.

As discussed in Section II.B, Elefante Group payload elements aboard STRAPS will include frequency converters, fast switches, and amplifiers to provide scalable, any beam-to-any beam switching capabilities at low SWaP. As a result, a single STRAPS will be able to connect UTs within its coverage area without the need to rely on any ground networks or equipment (apart from the UTs). Thus, for example, multiple locations of a local government, institution, or enterprise could be connected in a private network relying solely on the on-board capabilities of the STRAPS. At the altitude of STRAPS, the latency will be on the order of 5 ms or less, comparing favorably with ground-based deployments at up to 80% cost reduction or more by avoiding the need to rely on ground infrastructure to connect and network UTs.

2. Feeder/Gateway Links

Elefante Group proposes to utilize up to 10 feeder/gateway links per STRAPS coverage area to connect the STRAPS to terrestrial IP transit or other ground-based transport where that is required. The feeder links will provide connectivity for users who require connections to the Internet, such as residential or commercial broadband end users. If a wholesale customer has need for connectivity to other terrestrial networks to serve its subscribers on the Elefante Group system, this, too, could be accomplished using feeder link capacity (or it may be accomplished using STRAPS-UT links—an advantage of a network in the sky—depending on the particular requirements). The actual connections to the terrestrial network to which the feeder sites are connected will be the responsibility either of Elefante Group as part of its wholesale service or assumed by its wholesale customer.

3. Description of C2 Requirements during Ascent and Recovery, Moving-to-Station and While at Station

Each FOC will utilize radio line-of-sight ("RLOS") and beyond RLOS ("BLOS") communications systems for C2 of platforms within its responsibility. In addition, each local

FOC will be integrated with another FOC that will serve as a redundant FOC for BLOS communications to the STRAPS. NOCs will provide platform positioning requests and will coordinate C2 functions of the communications network and communications payloads. Each airship will have a secondary or backup FOC and NOC for redundancy in case of the primary FOC or NOC experiencing a catastrophic failure.

The C2 needs of STRAPS will be handled by commercial satellite communications (especially BLOS), or use spectrum allocated for C2 communications for unmanned systems when in RLOS.[14]

Specifically, Elefante Group expects to use RLOS C2 during ascent and descent and BLOS provided by commercial satellite links during the STRAPS transit flight to its nominally fixed position. Once the STRAPS is in its nominally fixed position over the desired coverage area, Elefante Group envisions using primarily BLOS satellite-based links.[15]

Elefante Group does not, in this petition, seek rules to support C2 for STRAPS.[16] However, final SBCS rules should ensure that there are no provisions governing STRAP-UT links or feeder links would preclude in-band C2 communications.

4. Cross-Links between STRAPS

Elefante Group envisions the use of either RF channels or free-space optical (i.e., laser) links between STRAPS systems. Elefante Group STRAPS may utilize crossover links between STRAPS when ending the mission of one STRAPS and bringing in another at the same station to

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[14] *See Aerospace Industries Association Petition to Adopt Service Rules for Unmanned Aircraft Systems Command and Control in the 5030-5091 MHz Band*, RM-11798, filed Feb. 8, 2018.

[15] As stated elsewhere in this Petition, Elefante Group does not envision, or seek rules to provide for, payload communications operations of STRAPS-UT or feeder links while the STRAPS are in transit to or from station or during ascent or descent.

[16] *See* Comments of Elefante Group, Inc. in Support, RM-11798 (filed May 29, 2018).

serve a given area. The design will accommodate an airship-to-airship "handover" method by which users can be transitioned between serving STRAPS with continuity of service. Various technologies are being evaluated by Elefante Group and Lockheed Martin for use in the crossover links, including reusing frequencies from the service links, and "out of band" radio frequency solution, or free space optics.

While this Petition does not make any particular proposals regarding frequencies for cross-links, nothing in the rules adopted for SBCS-UT links or feeder links should preclude the use of the frequencies made available for those purposes from also being used for STRAPS-to-STRAPS links. In such cases, Elefante Group recognizes that some coordination may be required to use those frequencies to avoid interference with other STRAPS and incumbent uses. As Elefante Group continue to evaluate this issue, it will update the Commission's record.

C. Elefante Group's Target Timetable to Prototype and Initial Commercial Payload and Deployment of STRAPS in the US

Elefante Group will build an approximately two-million cubic foot prototype airship, or Alpha. Elefante Group and Lockheed Martin expect to be ready to begin construction shortly, and complete Alpha by late 2020. The Alpha will be the critical test platform for both testing key operational elements such as air worthiness, station keeping, and helium retention for long duration missions, as well as the myriad of communication tests to continue development of a 1 Tbps service using Ka-band spectrum. Experimental Ka-band spectrum will be requested for this test period. E-Band spectrum will also be needed to successfully test aspects of the complete communication system architecture. The communications components residing on Alpha will also allow field testing of compatibility and mitigation methods within the spectrum Elefante Group seeks to access to make SBCS a reality in the United States.

In parallel with the development and deployment of the Alpha airship system, Elefante Group and Lockheed Martin will be scaling the Alpha design to meet production airship requirements and communications payload, including significant software and production hardware development as well as large scale manufacturing, large new air dock facilities and other efforts required for a highly innovative system of this magnitude. This effort, which is scheduled to be fully underway in 2021 will result in a full-scale production prototype or Beta airship for launch in late 2021. Additionally, Elefante Group and Lockheed Martin will develop the FOCs, NOCs and terrestrial networks required for initial deployments in the 2022 timeframe when access to the shared bands that are the subject of this Petition will be used for operational flights and commercial communications.

IV. ELEFANTE GROUP WILL PROVIDE STRATOSPHERIC COMMUNICATIONS THAT MEET MULTIPLE GROWING SERVICE NEEDS AND ADVANCE KEY COMMISSION POLICY OBJECTIVES

SBCS platforms will be capable of supporting a variety of communications systems configurations in both urban and rural settings. A single STRAPS deployment can and will in most cases reach not only urban and suburban areas but inherently will be able simultaneously to provide similar capabilities throughout both semi-rural and rural areas within the platform coverage footprint as well. STRAPS with sufficient payload, such as that designed by Elefante Group, will also be capable of supporting remote sensing systems in addition to communications payload. The flexibility of the Elefante Group payload capacity will enable a variety of missions. While Elefante Group believes that the lift, duration, and power of its platform provides a significant advantage, specifically high persistence and station-keeping, a number of

other planned and demonstrated stratospheric systems that have been described to date,[17] have the potential to serve a variety of needs.

In meeting these needs, as described below, SBCS will also advance a number of key Commission objectives related to infrastructure, bridging the Digital Divide, facilitating network densification, maximizing spectrum usage, supporting communications during and after natural disasters, and creating American jobs.

A. A Durable, Persistent, Reusable, Reconfigurable Platform Makes Possible Multiple Efficient Customer Communications Applications

Elefante Group envisions SBCS operations supporting a variety of communications and sensing-based solutions uniquely suited to exploit the advantages of stratospheric operations. The baseline payload of a STRAPS could support 4G/5G cellular backhaul and network densification as well as filling in coverage gaps of providers in urban and rural areas, broadband access for businesses, enterprise wide area network connectivity, and broadband access for consumers in urban and rural areas *with the same payload*. Elefante Group plans to support all of these applications, as its total platform bandwidth can be allocated across all these usage scenarios simultaneously.[18]

All of the projected service offerings by SBCS systems are aided by certain characteristics of stratospheric-based deployments. Unlike their ground-based counterparts, SBCS will encounter fewer entanglements with the sorts of design obstacles and zoning delays

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17 Within operational parameters, Elefante Group STRAPS will support fast on-station time, station keeping over desired mission areas, short or long mission duration, and controllable and adjustable placement without relying on favorable winds.

18 Notably, a recoverable STRAPS platform provides flexibility to support regular technology upgrades in between missions of short or long duration as desired by the particular payload mission. The payload can be readily accessible for maintenance or upgrade depending on the operational needs. Entirely new payloads can be planned, outfitted, and flown in rapid order. Other specialized payloads can easily be developed with a well-defined interface specification for power, mass, and physical interfaces to the platform.

associated with the construction and upgrade of wireline and wireless ground-based network facilities. STRAPS will not have to trench and deploy miles of fiber, install multi-hop microwaves, nor construct the environmentally controlled points of presence for switching, routing, and optical equipment. STRAPS will have to acquire a few zoning permissions at various nodes along the network where capacity is desired. Indeed, in order to connect two fixed terminals within the approximately 15,400 square kilometer (6,000 square mile) footprint, an SBCS provider needs only to install the two fixed user terminals, thereby bypassing multi-hops of microwave and fiber, switching and routing and other elements of a traditional wireless network. Multiple SBCS-UT links connecting multi user terminals creates an efficient distribution network throughout a metropolitan or wide area. Similarly, as technologies evolve, a STRAPS network upgrade will be prompt and coverage area wide with one change out of a STRAPS during regular handover cycles.[19]

1. 4G and 5G Backhaul Service. High capacity SBCS such as Elefante Group's will be able to offer 4G and 5G backhaul services efficiently, providing high speed connectivity within a platform footprint between cellular sites and mobile switching centers and/or aggregation points in a mobile network operator ("MNO") backhaul network. High speed, low latency service, which the Elefante Goup SBCS will provide, is critical for supporting backhaul for 4G and 5G networks. Rapid switching of traffic between beams on a STRAPS will allow point-to-point and point-to-multipoint connectivity between cell sites and mobile switching centers, regardless of the type of cell site served. Once an area is being served by a STRAPS,

[19] In many cases, except where there is a change in frequencies or channelization, or waveform, for example, UTs would not have to be changed as a result of an upgrade of the STRAPS radios. Elefante Group acknowledges that, even with an SBCS bypassing the many intermediate infrastructure requirements and obstacles, UTs will still face the need to meet antenna siting requirements. But there is no doubt that the overall burden of covering a metro-wide area, and upgrading it, is significantly less.

deployment to cell sites is rapid as compared to deployment of fiber networks, presenting an "instant-on" capability within a platform's entire footprint.

Small cells can easily be supported with SBCS service, especially with advanced deployment techniques for small cells. Multiple backhaul methodologies are now planned for small cells, including fiber, point-to-point microwave, mesh networks, point-to-multipoint microwave, and LTE UE Relay. Each has advantages and disadvantages with applications relevant to circumstances of a given deployment scenario. STRAPS-based backhaul services can be used to provide more flexibility in small cell, microwave, or mesh site selection. Being able to quickly deploy SBCS service can reduce the number of hops required in a mesh network, potentially to zero, as well as eliminate the need for multi-hop microwave systems. Similarly, SBCS backhaul service can be used in the placement of small cells in the middle of residential or more rural neighborhoods where fiber backhaul may not be available, as well as in the many urban fiber and wireless deserts that still exist. The availability of SBCS backhaul service and a STRAPS network capability provides more flexibility in small cell placement. Planned development of electronically steerable array-based ("ESA-based") UTs will support even more flexibility in small cell deployments.

SBCS backhaul services can also be utilized in supporting robust deployment of distributed antenna systems ("DAS") and centralized or "cloud" radio access networks ("CRAN") being used to densify 4G and 5G networks. With each DAS and CRAN deployment strategy, a headend location is required that contains the supporting baseband equipment. SBCS will enable these deployments to be more flexible in the selection of a headend location if a fiber locations are not optimized. The headend or central equipment can be located optimally to match wireless propagation and capacity requirements. Capacity can be incrementally added

where needed within the STRAPS coverage area, without the need for additional roof rights, fiber rights of way, multi-hop backhaul technologies, tall infrastructure for microwave, or delay in deployment required for fiber physical build out.

In the planned Elefante Group deployment, backhaul services supporting 4G and 5G roll-out will be supported by the capacity, network switching capabilities, and persistence of the STRAPS platform. The system minimizes terrain impediments that block microwave or increase costs of fiber builds. Indeed, Elefante Group's studies indicate that the reduction in cost, both upfront and during the ongoing provision of service, will reduce link costs within a metro area by 70-90% on average over ground-based deployments.[20] The low latency meets the requirements of cellular backhaul. Additionally, traffic termination can be switched between points in the network based on quick reconfiguration of switching on the STRAPS, supporting rapid changes in network traffic flow in response to terrestrial network issues. Quality of Service ("QoS") features will also be present on the Elefante Group SBCS system to meet the requirements of cellular backhaul.

<u>2. Enterprise WAN Service.</u> SBCS can also enable enterprise wide area network ("WAN") services. High capacity, secure connections between multiple enterprise locations within a platform footprint will be supported by the Elefante Group STRAPS, for example, by fast any beam-to-any beam switching of traffic on the STRAPS itself. Such connections will be

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[20] Elefante Group has extensively modeled the cost of its proposed STRAPs communications services and expects to be able to deliver a substantially lower cost per bit per square kilometer than either terrestrial or satellite services while maintaining performance comparable to terrestrial systems in terms of capacity and latency. Elefante Group is able to achieve such a low cost because of the long-endurance of its STRAPs, their ability to carry a large payload, the highly efficient spectrum re-use of the communications design and the low cost of operating and maintaining a recoverable, airborne platform. Elefante Group's analysis suggests that this cost advantage will be evident both when compared to new deployment scenarios as well as over-build scenarios on a total cost of ownership basis.

made with low latency as connecting through a gateway will not be required. Elefante Group's Enterprise WAN services support point-to-point or point to multipoint connectivity between buildings on a campus or buildings across town. Enterprise features such as quality of service and virtual private networking will be supported by Elefante Group for this service.

3. Fixed Broadband Access. STRAPS-based residential and small to medium business ("SMB") fixed broadband services offerings will reach remote, rural, and urban users and help end the Digital Divide with minimum infrastructure deployment and at much lower cost.[21] For example, the Elefante Group system will provide high capacity, low latency service across the entire service area of a STRAPS. In urban areas, by bypassing the need for intermediate infrastructure access, Elefante Group estimates that its service will cost at least 80% less than most ground-based terrestrial services for comparable performance, including links supporting 5G. Significantly, once STRAPS is deployed, there will be no urban "broadband deserts" as may exist with other technologies in locations within a geographic license area where infrastructure is too costly or not available. Service will be received with professionally installed UTs not dissimilar to end user equipment of current satellite video and broadband systems.[22] SBCS fixed service offerings can be to individual end user locations, or support service to and distribution within multiple dwelling units, at the discretion of the customer.

SBCS fixed broadband service can be just as easily provided across urban, suburban, or rural areas within a STRAPS footprint. An SBCS broadband communications system provides for nearly uniform capacity within each beam in the STRAPS' entire coverage area. Even if centering a service area on an urban area, except in the very largest markets there will be

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[21] *See infra* Section IV.

[22] Future developments to further reduce UT antenna sizes and make placement more flexible is likely.

significant capacity that extends into rural areas. In large urban coverage areas, multiple STRAPS may be required to cover the area which means that surrounding suburban and rural coverage can still be significant, even where the primary coverage area is urban.[23]

Similar to fixed broadband services for residential and small business end users, a spectrally efficient high-capacity SBCS can support broadband connectivity for enterprise end users. SBCS will support enterprise features such as quality of service and virtual private networking. The connectivity can be primary or backup to enterprise locations including data centers. A stratospheric system will provide a unique backup capability with features and resiliency, such as the ability to quickly respond to instant capacity surges and link the traffic to another network node in the service area or not be dependent on the same power grid, which are constraints that apply to terrestrial networks.

B. SBCS Can Also Support Numerous Combined Communications and IoT Applications

SBCS platforms combined with remote sensing capability at stratospheric heights through application of existing technologies can support any number of industries from agriculture to public safety. Support for wide area deployment of communications tailored for IoT connectivity will supply significant bandwidth for those IoT applications that need high bandwidth. Additionally, multi-mission payloads may support broadband service combined with sensor capability during the same mission.

For example, Elefante Group's planned IoT Enablement and Management Services will deliver focused solutions for IoT use cases across multiple applications over the ubiquitous coverage in a STRAPS service area. The ability to provide backhaul and networks services to

23 With the capacity and low latency provided by the broadband communications system, real-time applications can be supported, including distance learning, telemedicine, video streaming, and telephony. Multicast service can also be supported.

any location with an UT provides location flexibility for video cameras, traffic sensors, road condition monitors, and other ground-based sensors. Additionally, sensors can be mounted on the platform itself for a large field of view. Possible candidates are Wide-Area Motion Imagery cameras, radar/LIDAR, environmental sensors or localized weather instruments. Both options—support of ground-based sensors and platform-based sensors—can support various programs such as Intelligent Transportation Systems and other Smart Cities initiatives.

Smart Cities initiatives include better traffic management, active public safety improvements and real time situational awareness, all of which can be augmented with cameras and sensors. A city can even offer broadband services in areas of special interest: urban broadband deserts, low income areas, public housing, intermittently deployed job and technology training facilities, and public areas and buildings as a part of Smart City engagements. By significantly lowering the cost of deployment, automated city services can be deployed where best utilized by the citizenry instead of only being available in centralized locations as dictated by ground-based carrier deployments, which may be, in any event, beset by delays that SBCS will not experience. Cost savings and citizen engagement are distinct improvements expected from SBCS-supported Smart City applications.

Ubiquitous coverage from a STRAPS can also be used to support Smart Grid deployments. Utilities are utilizing multiple wireless and wired techniques to improve communications along and within their electrical distribution facilities. However, many utility facilities are older and do not include co-located fiber deployments. The ability to provide communications facilities anywhere and everywhere within a STRAPS service area can support the addition of sensors and active devices within electrical distribution facilities. The same can be said for water and sewer facilities.

SBCS will also be ideally suited for precision agriculture applications, which combine weather, remote sensing, and data distribution capabilities.[24] These are but a few applications of IoT systems that can be supported and incented through the availability of a persistent, ubiquitous STRAPS platform.[25]

C. Adopting a Regulatory Framework That Allows SBCS Solutions to Become a Reality Will Advance National Objectives

Establishing the requested regulatory framework will stimulate investment in persistent stratospheric solutions allowing them to bring significant public benefits that advance numerous high-priority Commission objectives. These include U.S. leadership in the early deployment of 5G services and infrastructure, closing the Digital Divide, supporting densification and deployment of next-generation networks, enabling robust IoT applications, creating American

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24 *See generally*, IBM Research, *Precision Agriculture*, available at https://researcher.watson.ibm.com/researcher/view_group.php?id=8068.

25 Remote sensing payloads are a natural addition as STRAPS payloads, as solo packages dedicated to the purpose of the package or as adjuncts to broadband communications payloads. For example, remote sensing package can be developed for potential use cases such as vehicle tracking and fleet management for logistic/transportation; surveillance and reconnaissance for various applications (metropolitan security, border security, defense, compliance, etc.); emergency services, disaster relief and insurance support; agriculture and fisheries support; environmental monitoring; energy and mining exploration and production support for remote areas; drone operations and tracking support; navigation and situational awareness support for autonomous vehicles; augmentation of existing satellite-based Positioning, Navigation, and Timing ("PNT") services; air-traffic control precision landing guidance and air space utilization optimization support; and mapping and GIS services. Ultra-high resolution sensors in the stratosphere would have significant complementary advantages as required by certain use cases over satellite payload, most notably the proximity to the observed area. Sensors could be hyper-spectral and specialized for exact mission outcomes. A large STRAPS platform, such as that designed by Elefante Group and Lockheed Martin, provides many favorable characteristics for remote sensing services. The available mass and power for a payload is considerably larger than many other platforms, offering not only persistence over an area of interest but also flexible upgrade potential as STRAPS are rotated. Remote sensors can be combined with the appropriate bandwidth system needed for instrument data download. The modular design of the broadband communications payload allows for rapid and specialized reconfiguration to support remote sensing requirements, be they passive or active sensors.

jobs, optimizing spectrum utilization and sharing in millimeter wave ("mmW") and other new frequency bands, and enhancing public safety communications and disaster response.

1. Enabling SBCS Will Spur Deployment of Efficient Broadband Infrastructure Aiding the U.S. in Efforts to Win the 5G Race and Stay in the Lead

The Commission has long recognized the significant challenges providers face when building out broadband networks. In its 2010 National Broadband Plan, the Commission described the need to remove infrastructure and other regulatory obstacles to broadband deployment and, in so doing, encourage competitive entry, innovation, investment, and network upgrades.[26] Elefante Group applauds the Commission for continuing to address the obstacles to buildout of conventional and next generation ground-based systems through, for example, its *Wireline* and *Wireless Infrastructure Proceedings*. But Elefante Group respectfully submits that the Commission should also take actions to spur deployment of innovative and far-reaching broadband deployments such as SBCS that *can bypass those hurdles and rapidly deliver turn-key, market-wide advanced, high capacity services*.[27]

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[26] *See* FCC, *Connecting America: The National Broadband Plan*, Executive Summary at xii (rel. Mar. 17, 2010), available at https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf.

[27] *See Accelerating Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment*, WC Docket No. 17-84, Notice of Proposed Rulemaking, Notice of Inquiry, and Request for Comment, FCC 17-37, (2017); *Accelerating Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment*, WC Docket No. 17-84, Report and Order, Declaratory Ruling, and Further Notice of Proposed Rulemaking, FCC 17-154, (2017); *Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*, WT Docket No. 17-79, Notice of Proposed Rulemaking and Notice of Inquiry, FCC 17-38, (2017); *Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*, WT Docket No. 17-79, Report and Order, FCC 17-153, (2017); *Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Deployment*, WT Docket No. 17-79, Second Report and Order, FCC 18-30 (Mar. 30, 2018).

This Petition gives the Commission a timely opportunity to do just that. SBCS systems, such as the ones Elefante Group is planning, will be capable of delivering substantial broadband capacity rapidly and cost-effectively to support, among other things, deployment of 5G capabilities both in urban and non-urban areas while avoiding many of the major hurdles that plague ground-based broadband deployments. Adopting rules that permit SBCS to access adequate spectrum and commence deployment, the Commission will promote solutions, as described above in Section IV.A. that avoid the challenges inherent with other delivery systems, while it continues the process of lessening those challenges for other broadband components of the 5G ecosystem, including the order of magnitude of network capacity needed to support the high number of high capacity 5G wireless sites (including the expected ground-based 5G deployments).

As a result of the foregoing, a stratospheric network would be significantly less costly than a terrestrial network serving the same market and surrounding areas to deploy a similar amount of backhaul and distribution capacity in a comparable coverage area. Consequently, adopting rules to promote investment in and deployment of SBCS will promote investment in a cost-efficient next generation infrastructure.

In short, by adopting a regulatory framework for the deployment of SBCS in a timely manner, the Commission will be promoting the type of infrastructure – broadband infrastructure – that is key to the roll out of next generation systems. This will give a positive jolt to the U.S. in its efforts to both win the race for 5G and, given the distinct advantage of SBCS for near instantaneous, market-wide upgrade deployment capability, stay ahead.

2. Deployment of SBCS Will Help Close the Digital Divide

Establishing service, operational, and licensing rules to enable deployment of SBCS will play an important role in bridging the Digital Divide. Near the top of the list of the

Commission's central goals is expansion of broadband in rural, remote, unserved, and underserved areas. Earlier this year, the Commission concluded that "[f]ar too many Americans remain unable to access high-speed broadband Internet access, and we have much work to do if we are going to continue to encourage the deployment of broadband to all Americans."[28] In particular, the Commission noted that "over 24 million Americans still lack fixed terrestrial broadband at speeds of 25 Mbps/3 Mbps" and that "14 million rural Americans ... still lack mobile LTE broadband at speeds of 10 Mbps/3 Mbps."[29]

STRAPS are uniquely positioned to advance the Commission's goal of universal service due to their deployment and capacity advantages over other systems. With Elefante Group's stratospheric solutions, for example, deployment of a single platform will cover 15,400 km^2 (6,000 mi^2). Often, the single greatest obstacle to terrestrial network buildouts in remote and rural areas – areas with fewer potential customers and frequently challenging topographical features –is the associated economic costs of buildout relative to potential return on investment. However, since STRAPS platform will operate under line-of-sight conditions to UTs, STRAPS are effectively agnostic with respect to population density and topography.

Notably, when an Elefante Group STRAPS is deployed, for example, the turn-key capabilities and capacity that will be made available in the more densely populated portions of the market will also be *instantaneously and inherently* made available to the entire 6,000 square mile footprint. Unlike ground-based buildouts in millimeter wave spectrum, which may target and prioritize coverage in certain areas over an extended construction schedule, an SBCS

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28 *See Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, GN Docket No. 17-199, Broadband Deployment Report, FCC 18-10, ¶ 6 (Feb. 2, 2018).

29 *Id.*, ¶¶ 50-51.

deployment will bring capability to an entire region, which in most markets will include surrounding non-urban areas. Elefante Group intends to deploy in regions surrounding its initial STRAPS coverage areas, as well as in smaller new markets, such that STRAPS service footprints would cover even higher percentages of rural and low-population territory.

In rural deployments, the impact of such near instantaneous availability of service would be tremendous, if not transformational. Moreover, in less urban ground-based deployments, licensees may focus on satisfying some minimal substantial service requirements to secure retention of the license or qualify for renewal, with a complete roll out deferred until some day in the future. And SBCS will also reach those persistent "urban deserts" within almost all metro areas that otherwise are reasonably well serviced.

Satellites are a key part of the solution to reach end users rural and remote areas. Many High-Throughput-Satellites ("HTS") are projected to provide over 100 Gbps capacity per satellite. [30] Such operations will have many applications and are a significant improvement over capacity on legacy FSS operations. Elefante Group believes that its stratospheric platforms could complement such satellite-based solutions well where more capacity may be required, drawing upon Elefante Group's bi-directional 1 Tbps connectivity in a service area on a scale much smaller than a single satellite beam, or where lower latency is needed due to their close proximity to the earth.

SBCS will be able to materially enhance connectivity for other providers as a backhaul application in rural areas. Due to the broad coverage area provided by each stratospheric platform, STRAPS can provide coverage and capacity where terrestrial and satellite-based

[30] *See, e.g.*, Vizocom, *The Future of High Throughput Satellites for Service Providers*, available at: http://www.vizocomsat.com/blog/future-high-throughput-satellites-service-providers/.

backhaul solutions providing both might not be feasible. In rural or suburban areas where broadband infrastructure must be deployed over a wide area to be economically viable, SBCS could provide backhaul links between platforms and aggregation points such as cell towers or WiFi Access Points or create a WAN across many user terminals. STRAPS could also function as data relay stations, receiving and forwarding information from satellites to end users.

In summary, SBCS systems, like those Elefante Group is planning, will make key contributions to closing the Digital Divide. While the Commission should continue to pursue a range of initiatives to close the Digital Divide, Elefante Group respectfully submits it is critical for the Commission adopt a regulatory framework that facilitates SBCS solutions as part of its overall strategy.

3. SBCS Will Support Network Densification and Deployment of Next Generation Networks

Persistent stratospheric solutions designed with high capacities will have the ability to support network densification efforts and augment the deployment and capacity of next-generation networks as described above in Section IV.A. This is notable because a subset of SBCS, namely services supported by the potential future deployment of high altitude platform stations ("HAPS"), have gained a lot of attention as an Internet connectivity solution outside of urban areas. But as the earlier description of Elefante Group's planned systems makes clear, SBCS is capable of much, much more, than providing a base level of Internet connectivity where none currently exists.

For years, service providers have been augmenting existing 3G, 4G, and LTE systems by densifying their network via deployment of small cells, DAS, and related technologies.[31] It is

[31] *See, e.g.*, AGL, *AT&T's Investment Provides Validation for Small Cells*, at 1 (2012), available at https://www.aglmediagroup.com/atts-new-investment-means-more-small-cells/ ("Announcing its $8 billion in wireless initiatives in the next three years on Nov. 7, AT&T noted

also widely understood that next generation networks, such as 5G, with operations as higher frequencies will depend on further network densification, which will require solving the increasing problem of backhauling the communications to and from this ever larger number of high capacity cells.[32] SBCS—by deploying a STRAPS with market wide turn-key coverage and the installation of UTs—will be well suited to support the current and planned network densification efforts. SBCS will serve as an efficient backhaul option for strings of small 5G cells or WiFi hot spots deployed outside as well as in buildings without having to install additional fiber capacity for primary or redundant local loop.

In addition, based on standard economic considerations, deployments of high-speed fiber broadband service are often confined to wealthier communities, with lower-income neighborhoods in urban areas relegated to lower speed service.[33] High capacity persistent

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that 'network densification' would be a large component of Project Velocity IP. Large, in this case, is bringing 40,000 small cells and 1,000 more DAS networks online."); Phil Goldstein, FierceWireless, *Analysts: Sprint's network densification project will likely include 70K small cells*, at 1 (2015), available at https://www.fiercewireless.com/wireless/analysts-sprint-s-network-densification-project-will-likely-include-70k-small-cells ("According to financial analysts who follow [Sprint], the Next Generation Network program will include around 70,000 small cells, some unknown number of additional macro cell sites and will likely involve wireless backhaul technology using the 2.5 GHz band.").

32 Wells Fargo research indicates that "Zayo's management estimated that each national carrier would likely need 150,000 to 400,000 small cell sites each over time, which would equate to 600,000 to 1.6 million in total across the Big 4" mobile carriers. Colin Gibbs, Fierce Wireless, 5G to lift Crown Castle, American Tower, many others: Wells Fargo, Fierce Wireless, (2017), available at http://www.fiercewireless.com/wireless/5g-to-lift-crown -castle-american-tower-many-otherswells-fargo. *See also*, Phillip Tracy, RCR Wireless, *What is Network Densification and Why is it Needed for 5G?,* at 2 ("Providing high system capacity and high per-user data rates –requirements for the creation of a 5G network – will require a densification of the radio access network or the deployment of additional network nodes. By increasing the number of cells, the traffic per square-meter can be increased without requiring a corresponding increase in the traffic that needs to be supported per network node, and by increasing the number of network nodes, the base-station-to-terminal distances will be shorter with a corresponding improvement in achievable data rates.").

33 *See* Haas Institute Policy Brief, "AT&T's Digital Divide in California," at 4-5 (2017) ("The median household income of California communities with access to AT&T's fiber-to-the-

stratospheric solutions can avoid many of the rights of way and other costs and deploy over an entire urban area, including higher and lower income communities alike.

4. SBCS Will Enhance IoT-Enabled and Sensor Applications

By virtue of their wide area coverage, high throughput capacity, proximity to the ground, and flexibility with respect to payload configuration, SBCS can play an essential role in enabling new capabilities in the burgeoning IoT. Stratospheric platforms, such as Elefante Group's large payload mass allocation of > 1,000 kilograms and payload power budget of 10 kilowatts, will be able to combine communications and sensing capabilities in customizable payloads to enable advanced IoT applications relying on a variety of data collection and relay capabilities as Elefante Group described in more detail in Section IV.B above. These applications include Intelligent Transportation Systems and support for autonomous vehicles, Smart Cities, the Smart Grid, and agriculture.

5. SBCS Will Promote Increased Spectrum Utilization and Efficiency

Elefante Group's persistent stratospheric platforms will efficiently maximize spectrum utilization by optimizing spectrum compatibility in encumbered spectrum, as detailed extensively below and in the Appendices to this Petition,[34] and employing heavy spectrum re-use. Maximizing and optimizing use of our nation's spectrum resources is a longstanding and fundamental objective of the Commission.[35] In its *Wireless Infrastructure* proceeding, the

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home (FTTH) network is $94,208. This exceeds by $32,297 the $61,911 median household income for all California households in the AT&T wireline footprint" and "AT&T's slow speeds are not limited to rural areas. In Los Angeles county, for example, approximately 443,000 households (20.4 percent) in AT&T's wireline footprint lack access to AT&T broadband at 6/1 Mbps and approximately 1.1 million households (51.5 percent) lack access to AT&T broadband at 25/3 Mbps.").

34 *See infra* Section VII.C-D. & Appendices A-U.

35 *See, e.g.*, FCC, *Strategic Plan of the FCC*, at 2, available at https://www.fcc.gov/general/strategic-plan-fcc. ("Efficient and effective use of non-federal spectrum domestically and internationally promotes the growth and rapid deployment of

Commission emphasized that "next-generation wireless networks… will increasingly need to rely on network densification, *whereby spectrum is reused more frequently*."[36]

Elefante Group and Lockheed Martin have been designing for spectral compatibility from the outset, which effectively is a major type of spectrum reuse and spectrum benefit maximization.[37] To gain access to the spectrum requested in this Petition, SBCS will not require exclusive access to spectrum among co-primary users. Conversely, the introduction of SBCS into this spectrum will not freeze growth of incumbent uses going forward. As a result, the introduction of SBCS into the bands will not create the typically substantial collateral issues associated with relocation or freezing of existing users, which confronts incumbent users with the task of finding another spectrum home, which may not be fully comparable, increases costs, and imposes additional costs and prospective constraints on others incumbent uses already in the new spectrum home.

Moreover, Elefante Group's design is such that multiple SBCS providers using competing high-altitude platforms would be able to operate in the same spectrum in the same area. With sufficient lateral separation, multiple STRAPS of different designs can effectively

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innovative and efficient communications technologies and services."); FCC, *Fiscal Year 2015 Budget Estimates Submitted To Congress*, at 1, available at https://apps.fcc.gov/edocs_public/attachmatch/DOC-325947A1.pdf, (stating the following agency strategic goal: "Maximize the availability of spectrum in order to provide diverse and affordable communications services to consumers.").

36 *See Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Deployment*, WT Docket No. 17-79, Second Report and Order, FCC 18-30, ¶ 1 (Mar. 30, 2018) (emphasis added).

37 This compatibility is achieved in large part because of the stratospheric platform geometry, creating directional and spatial diversity relative to incumbent uses, and the small size of the platform's beams which enables considerable flexibility in beam lay-down patterns and a high level of frequency reuse. Elefante Group and Lockheed Martin will rely upon the application of other mitigation methods to enhance compatibility.

reuse spectrum to serve a given area, deriving additional capacity with additional STRAPS while servicing the same coverage as Elefante Group, respectively.[38]

In addition to the effective spectrum reuse represented by the introduction of SBCS into encumbered spectrum, SBCS systems themselves will be capable of spectrum efficiency. For example, communications payloads deployed on Elefante Group's STRAPS will utilize a high degree of frequency reuse within an operating radius of 70 km to achieve a high level of spectrum efficiency. Elefante Group's communications payloads will reuse each channel in a cellular pattern of hundreds of spot beams. Reuse will occur >130 times within the footprint of each Elefante Group platform.[39]

D. SBCS Deployed in the United States will Create American Jobs

Enabling the deployment of persistent stratospheric communications systems will create American jobs. Elefante Group anticipates that, within a few years of launching commercial operations in the early 2020s, it will have created thousands of new American jobs in areas such as technology development and engineering, manufacturing of components and systems for airships, communication and sensor platforms, construction and operation of airship facilities, construction of airships and payload integration, manned FOCs and NOCs, ground systems operations including network and user terminal installation, as well as related positions such as sales, marketing and administration.

E. SBCS Can Efficiently Restore Communications Following Natural Disasters

One of the fundamental mandates of the Commission is to ensure the availability of a "Nation-wide, and world-wide… communication service with adequate facilities . . . for the

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38 *See infra* Section VII.D.

39 Elefante Group's payloads will achieve over 450 bps/Hz in spectral efficiency on an aggregate basis across a single platform's service area.

purpose of promoting safety of life and property."[40] In response to a particularly severe hurricane season in 2017 in which four hurricanes made landfall in the US and its territories, the Commission put out a Public Notice seeking comment on resiliency of network infrastructure, effectiveness of emergency communications, and government and communications industry responses to the 2017 hurricane season.[41] As Elefante Group explained in its comments on the Commission's *Hurricane Public Notice*,[42] the company envisions that the advantages of stratospheric communications solutions, such as the one it is developing, will dramatically improve the resiliency and robustness of the communications infrastructure before, during, and after severe weather events or other natural disasters.

Stratospheric platforms operating at fixed locations can both bolster the communications infrastructure in a way that is significantly weather-resistant and perform other services for multiple customers throughout the emergency or disaster cycle. This is because stratospheric platforms fly above virtually all storm systems that can take out portions of ground-based communications networks. With very few exceptions, the atmosphere at 65,000 feet is sufficiently stable to enable operations over and around a hurricane based on Elefante Group's discussions with the National Hurricane Center and the National Aviation Weather Center.[43]

Persistent stratospheric solutions will offer an "aerial regional network" and are designed to link one network node to another network node, or link an end user, residential or business, to a network node to another end user. Any existing, pre-disaster customer or network provider

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40 *See* 47 U.S.C. § 151.

41 *Response Efforts Undertaken During 2017 Hurricane Season*, PS Docket No. 17-344, Public Notice, DA 17-1180 (rel. Dec. 7, 2017) ("*Hurricane Public Notice*").

42 *See Elefante Group Hurricane Public Notice Comments* at 5-7.

43 *See Id.* at 6.

that is connected to a stratospheric platform under normal deployment and operations, provided their node has access to either primary or an alternate power and any required gateways, would be able to bypass damaged or missing terrestrial infrastructure. The Elefante Group STRAPS on-board switching capability to shift traffic from any beam to any other beam in the 6,000 mi^2 area makes any required terrestrial infrastructure related to the SBCS much more resilient and faster to recover to full capacity if affected by a natural disaster.

Furthermore, stratospheric airship-based communications can also provide high capacity, low latency broadband services via authorized spectrum to complement and facilitate the reconstitution of the ground-based communications infrastructure. Where needed, an additional SBCS could be deployed to provide further capacity in a hard-hit market on a temporary basis after a storm.

Finally, stratospheric platforms, in appropriate circumstances, could prospectively also fly in front of a storm providing emergency and complementary communications services under a broad footprint as ground-based communications are adversely impacted.[44] In addition, stratospheric platforms with appropriate sensor equipment can roam and surveille above and in the projected path of a weather event, in effect "mapping" pre-storm sensor data.

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For the foregoing reasons, implementing rules permitting SBCS to operate in the requested spectrum bands will serve the public interest in significant ways and promote the achievement of important Commission and national objectives in ways that other platforms,

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[44] The illustrations of roving operations described in this paragraph are not the type of deployments for which Elefante Group asks the Commission to adopt rules for here. But such capabilities, if STRAPS are supported through rules for fixed operations, could be developed and made available drawn upon in an emergency with appropriate STA authority and, if necessary, waivers.

ground-based and in-orbit, cannot. The Commission should ensure that SBCS can gain access to appropriate spectrum bands to allow these substantial complementary solutions to become a reality, whether to win the race to 5G, bridge the Digital Divide, introduce advanced IoT capabilities, densify networks in urban areas, maximize reutilization of spectrum resources, create jobs, and make communications more resilient in the wake of natural disasters.

V. PERSISTENT STRATOSPHERIC PLATFORMS PRESENT MANY OPERATIONAL ADVANTAGES FOR NEXT GENERATION NETWORKS THAT WILL COMPLEMENT OTHER DELIVERY SYSTEMS

SBCS systems are able to offer distinct advantages relative to other communications platforms. Because of these advantages, stratospheric systems, in addition to ground-based fixed and mobile networks and with satellite systems, will occupy important roles in this country's next generation network ecosystem. All platforms – ground, satellite, and stratospheric – should be facilitated within this nation's regulatory framework to maintain this country's leadership role in advanced communications.

SBCS will assume an important role in realizing the promise of 5G, both in delivering service capabilities directly to end user locations – fixed wireless access or enterprise WAN, for example – and in providing efficient, rapidly deployable, and easily-upgradable high capacity backhaul across markets requiring minimal infrastructure. The Commission should ensure adequate access to spectrum on a timely basis is available to stratospheric platforms to achieve the promise of advanced SBCS systems.

As is discussed in the remainder of this Section, Elefante Group's stratospheric solution will make important contributions to next generation capabilities and deployment with respect to deployment efficiency, spectral efficiency, payload, scope of coverage, customizability, network adaptation, and communications during and after natural disasters.

A. Deployment Efficiency

When a single STRAPS is deployed, its communications payload capabilities are immediately extended to its entire coverage area. Operating at 18 km or greater altitudes, STRAPS will have coverage areas on the order of 70 km radius, or approximately 15,400 square kilometers (6000 square miles). As a point of comparison, the Washington Metropolitan Area consisting of the District of Columbia, seventeen counties in Virginia, Maryland, and West Virginia, and six independent cities, is 5,565 mi^2.[45] Much of the area in this example is rural.[46] The significant and substantial positive consequences of this are several. First and foremost, this means that substantial wireless network capabilities can be brought to a wide area virtually instantaneously.[47] This stands in comparison to ground systems which can take many months or many years to deploy a network over a comparable area and require the installation or upgrading of network elements (antenna and routers, for example) provided by many different vendors. Moreover, as described in Section IV.A, STRAPS can effectively sidestep many of the administrative and regulatory obstacles associated with ground-based deployments that typically create the biggest challenge and impose many of the costs for network deployments.

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45 *See* "Capital Facts for Washington DC," Worlds Capital Cities, accessible at https://www.worldscapitalcities.com/capital-facts-for-washington-d-c/. More specifically, the metropolitan area includes, in addition to the District of Columbia, the following counties and independent cities: Maryland: Calvert County, Charles County, Frederick County, Montgomery County, and Prince George's County; Virginia:, Alexandria, Arlington County, Clarke County, Culpeper County, Fairfax County, Fairfax, Falls Church, Fauquier County, Fredericksburg, Loudoun County, Manassas, Manassas Park, Prince William County, Rappahannock County, Spotsylvania County, Stafford County, and Warren County; West Virginia: Jefferson County.

46 The foregoing comparison is one of size not shape. Elefante Group does not mean to suggest that the entire Washington Metropolitan Area can be served with one STRAPS as the area is not circular, whereas STRAPS coverage areas will be effectively circular, subject to beam customization. However, the distance between the White House and Dulles International Airport is straight-line 36 km, or approximately half the practical communications radius of a STRAPS; that radius is designed to achieve an elevation angle of approximately 15 degrees to help ensure compatible operations.

47 Naturally UTs will still have to be deployed in specific locations on the ground.

The ability to upgrade rapidly over a large area as described above compares very favorably with other types of platforms.[48] Ground-based systems, as with initial deployments, can require many months to upgrade a network within a metropolitan area. While satellite systems have coverage advantages, they have higher latency and less capacity per square kilometer than STRAPS. Additionally, STRAPS has advantages on risks, costs, delays, and limitations associated with the life cycle of satellite systems. For example, satellite system components are difficult to modify after launch other than with software updates that provides some, but limited, ability to update or modify major performance characters.

As described earlier in Section IV.E., the rapid deployment capabilities of STRAPS and SBCS systems after a storm or other disaster compares very favorably with ground and space-based networks.

B. Spectral Efficiency

SBCS offer material advantages with respect to spectrum efficiency. Elefante Group's design, for example, will be able to achieve 1 Tbps in each direction over a STRAPS coverage area by combining advanced waveforms and radio systems achieving > 4.5 bps/Hz within each beam and significant frequency reuse. To provide 1 Tbps in "greenfields" or clear spectrum, Elefante Group STRAPS will require three physical 450 MHz bands for downlink plus an additional three physical 450 MHz bands for uplink. Utilizing right and left hand circular polarization STRAPS can deploy a six color reuse pattern. With a payload capable of generating 540 beams, spectrum will be reused greater than 130 times throughout a single STRAPS

[48] For example, each STRAPS has a modular payload that will be replaced in a seamless fashion when needed for service or upgrades, can reach operational altitude on their own power, and are environmentally friendly insofar as they will rely principally upon solar power.

coverage area. Spectrum reuse and, therefore, overall spectrum utilization, is multiplied when multiple STRAPS are deployed to serve the same areas in common spectrum.

Further, unlike at least some of the radio systems that are being planned for 5G and other next generation applications, SBCS will be extremely spectrum compatible. The technical parameters that Elefante Group describes herein, and which it urges the Commission to incorporate into its rules for SBCS, will allow for a variety of deployment designs while ensuring that SBCS systems are highly compatible with incumbent operations within the candidate bands. Elefante Group wishes to underscore that it is not looking to relocate or "freeze in place" any non-Federal services or Federal operations already operating in the proposed bands. To the contrary, introduction of SBCS into the full range of proposed spectrum bands is intended to ensure the ability for growth of incumbent uses. Significantly, Elefante Group has incorporated into the development of SBCS a "sharing by design" approach.

Indeed, SBCS is likely to do even better in this regard. As one example, fixed link deployments in the 21.5-23.6 GHz are non-exclusive. Every deployment today by a new fixed link creates certain limitations on future links in the same vicinity and aligned on the same or similar paths. Because of geometric diversity, UTs are always "looking up" and have a higher elevation angle than typical microwave hops, (e.g., the minimum elevation angle of SBCS UT deployments at the edge of a coverage area is 15 degrees) and so the impact of a UT deployment on future traditional fixed links in proximity will generally be less than that of a fixed link.[49] Moreover, with a notional deployment of STRAPS deployed directly over an urban area with coverage extending beyond urban to include rural, it is expected most SBCS-UT links will be

[49] Conversely, SBCS-UT links will generally experience less of an impact on subsequent deployment when a new traditional fixed link is deployed.

within the interior 50% of the of the coverage area with an even higher elevation angle, reducing the inter-link impacts even more.[50] This is discussed in more detail in the compatibility section of the Petition.

In short, because of Elefante Group's advanced system communication architecture, its significant spectrum reuse and highly compatible operations, SBCS will represent something quite unprecedented in terms of a model for spectrum access, and in particular spectrum sharing, maximizing spectrum utilization and efficiency through usage that that is interoperable with incumbent networks. An entirely new service offering and significant capacity is being proposed in the bands that are the subject of this Petition without materially affecting existing incumbent uses. Moreover, that this is being done by a service that will make major contributions to next generation networks is especially notable, demonstrating that a faster introduction of 5G and other capabilities into a spectrum band does not require relocating existing users or placing arbitrary, artificial limits on their growth. While the introduction of SBCS will involve some coordination in some sharing scenarios, to be sure, SBCS will represent a major advance in modern spectrum management and maximizing spectrum utilization and efficiency.

C. Latency and Data Rates

Compared to other overhead systems, such as satellites, STRAPS delivers lower latency and significantly higher and more flexible data rates for a comparable service area. Additionally, only a single STRAPS is needed to provide persistent services in the desired coverage area compared to the multiple non-geostationary orbiting ("NGSO") satellites needed to provide

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50 Fifty percent of the coverage area of a STRAPS resides within a distance of 49.7 km from the STRAPS nadir. The remaining 50% of the coverage area resides within the annular areas between 49.7 and 70 km. At this midpoint, a UT elevation angle would be approximately 22 degrees. Thus, most of the SBCS-UT links would result in UTs pointed at > 22 degree elevation angle.

consistent services. Moreover, Elefante Group's communication system will have the ability to meet "instant" additional capacity needs with competitive link data rates that Elefante Group believes will be well below the cost of many ground-based alternatives. Elefante Group envisions a mix of STRAPS and satellites could create an effective solution for rural areas as satellites have large coverage footprints and could fill in where STRAPS do not reach.

Due to the altitude and switching architecture of STRAPS, SBCS-UT links will inherently exhibit low latencies over a metropolitan area. Indeed, by bypassing significant infrastructure and systems between end points, the latencies of SBCS links will be comparable to, and in some cases better than, those of ground-based systems.

Advanced ground-based systems on 4G LTE networks typically have round trip network latencies in the range of 59 – 65 ms.[51] Satellite systems have latencies in the range between 599 – 629 ms if in geostationary orbit,[52] and some of the recent NGSO systems claim latencies on the order of 16 – 50 ms.[53] By contrast, a STRAPS, at approximately 19 km above the earth's service with Elefante Group's proprietary switching/routing capability inherent in the platform payload,

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51 Open Signal, *State of Mobile Networks: USA* (February 2017), available at http://opensignal.com/reports/2017/02/usa/state-of-the-mobile-network.

52 *Measuring Broadband America Fixed Broadband Report*, available at http://data.fcc.gov/download/measuringbroadband-america/2016/2016-Fixed-Measuring Broadband-America-Report.pdf, at 21.

53 *LeoSat MA, Inc. Petition for Declaratory Ruling to Permit U.S. Market Access for the LeoSat Ka-band Low-Earth Orbit Satellite System*, IBFS File No. SAT-PDR-20161115-00112, Petition of LeoSat MA, Inc., 4 (filed Nov. 15, 2016) ("[C]ommunications between two user terminals directly under a LeoSat satellite may take approximately 16 ms."); *Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, IBFS File No. SAT-LOA-20161115-00118, Legal Narrative, 5 (filed Nov. 15, 2016) ("*SpaceX NGSO Application*"), ("The system's use of low-Earth orbits will allow it to target latencies of approximately 25-35 ms."); *WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System*, IBFS File No. SAT-LOI-20160428-00041, Technical Narrative, 2 (filed Apr. 28, 2016) ("[U]sers on OneWeb's system experience round trip latency of less than 50 milliseconds.").

will have latencies within a platform footprint of < 5ms.[54] This compares favorably with expected latencies within ground-based 5G deployments. There is still no definitive, agreed upon target for 5G system latency, but there are some projected latencies between 4 -5 ms for mobile applications, and possibly lower in some cases. An ITU Draft Report from February 2017 uses a 4 ms benchmark for mobile broadband, and a 1 ms benchmark for what it refers to as "ultra-reliable and low-latency communications."[55] AT&T, touting its recent achievement of 9 ms latency, has stated that "the industry expectation for 5G is latency less than 5 milliseconds."[56]

Elefante Group, with its advance network architecture and resource management capability (the ability to parse the channel into multiple data rates) can provide a wide range of data rates to multiple UTs that meet the capacity demands of both enterprise and consumer users. STRAPS payloads can be modified to suit demand or upgraded as new technologies are developed, which is something satellites cannot do post launch.

In sum, SBCS latencies are an improvement on today's ground-based and satellite systems. Moreover, SBCS latency is entirely in keeping with latencies expected for 5G metro systems, and as such, combined with their other capabilities and comparative advantages including providing a wide range of data rates, it is clear that SBCS communications will be an essential element if the promises of next generation systems are to be achieved.

D. Service Area Customization

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54 In addition to latency, the lower altitude creates a number of other advantages for SBCS: lower power need because of the square of the distance RF transmission loss, the additional power and mass capability of an airship, the ability to use smaller beams to generate considerably more capacity per unit area, and the ability to update the communications hardware at the nominal six-to-nine-month maintenance intervals.

55 Working Party 5D, *Minimum requirements related to technical performance for IMT-2020 radio interface(s)*, Document 5/40-E, 22 February 2017, at 6.

56 John Brodkin, Ars Technica, *AT&T's 5G trials produce gigabit speeds and 9ms latency*, April 11, 2018, found at https://arstechnica.com/information-technology/2018/04/atts-5g-trials-produce-gigabit-speeds-and-9ms-latency/.

STRAPS operating at a nominally fixed location can provide persistent connectivity or operations over the entire potential coverage area. But the footprint of a STRAPS can be rapidly customized as required for compatibility or coordination, including near international borders. Flexibility with beam sizes, activated beams and ability to customize the footprint would allow stratospheric solutions to target unserved and underserved areas with a high degree of customizability as to footprint shape limited by beam size. On the Elefante Group system, for example, beams can be turned off or the frequency selection or reuse pattern in part of the coverage area can by modified. Moreover, STRAPS have the ability to adjust their nominally fixed location if necessary.[57] STRAPS can continuously provide wide area coverage that supplements the capacities of ground-based networks. At the same time, STRAPS present a versatile solution for individual end users and can effectively supplement or provide an alternative to certain terrestrial and satellite operations.[58]

E. The Elefante Group SBCS Has Operational Advantages Over Other Currently Envisioned High Altitude Solutions

A number of other companies are exploring unmanned stratospheric platforms to support the emerging communications and remote sensing markets that would qualify as SBCS. Brief

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[57] Moving the nominally fixed point of a STRAPS would involve re-coordination with other users, as needed, and Elefante Group anticipates this would only be undertaken in somewhat extraordinary circumstances.

[58] While not a communications capability *per se*, stratospheric platforms can carry payloads offering unique capabilities and capacity to end users. Elefante Group's planned STRAPS, with their large payload capacity, will allow a combination communications and significant sensing capabilities on the same platform that will create advanced IoT capabilities. In particular, by operating stratospheric platforms that persistently maintain nominally fixed points, their payloads can monitor various elements of their surroundings and underlying coverage areas that are unavailable to NGSOs (which are inherently non-geosynchronous) and GSOs (which are physically too far out of range for many types of data collection at the resolutions that STRAPS would allow). In this sense, STRAPS can clearly extend the capabilities of satellite systems with respect to earth observation, remote sensing, and navigation, and will clearly offer advantages that permit entirely new, persistent applications. Ground-based systems effectively do not have the same observational capabilities, although they will certainly offer complementary IoT capabilities from ground-based sensing better suited to their architecture.

summaries of four such systems are provided below as a point of comparison with Elefante Group's planned SBCS and illustrate the variety of possible SBCS solutions that are in development.

<u>Zephyr.</u> The Zephyr T, currently in-development by Airbus, is a solar-powered fixed-wing platform (wingspan of 33 m) allegedly capable of station-keeping while carrying a small (less than 20 kg) payload. The Zephyr T plans to fly at 65,000 ft. during daylight operations and slowly descend during nighttime. It is designed to fly continuously for a month before landing to be serviced. Three smaller Zephyr S platforms (with even lower payload-carrying capability) have been procured by the British Ministry of Defense. With its small payload as currently designed, Zephyr would have limited scalable commercial application in the United States.

<u>Aquila</u>. Facebook is developing the technology for Aquila solar-powered fixed-wing aircraft to further the company's goal of connecting an ever larger portion of the world's population to the Internet. Aquila is being developed to operate above 60,000 ft. altitude for up to 90 days carrying a modest payload to offer Internet access to a 60-mile wide area. A subscale version of the aircraft underwent two short-duration low-altitude test flights in 2016 and 2017. It is expected that significant additional engineering and development is needed to evolve Aquila into a full scale and viable platform.[59]

<u>Loon.</u> X (formerly Google) is developing a system of high altitude balloons under Project Loon in an effort to extend Internet connectivity to people in rural and remote areas worldwide. The goal of Project Loon is to deploy a large network of helium balloons flying between 60,000 and 80,000 ft. carrying very small (~10 kg) communication payloads capable of LTE services to 4G LTE handsets using carrier provided spectrum. The individual Loon

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59 *See* "Internet by Google Balloons & Facebook Drones," available at <u>https://www.youtube.com/watch?v=nTYCcNZBQCQ</u>.

balloons are capable of long duration flights (average flights of ~ 100 days). Loon employs an altitude control mechanism and weather forecasting tools in an effort to utilize the most favorable winds, speed and direction, to transit to and provide service over a desired coverage area. The station-keeping capability of individual balloons has been demonstrably limited, but the capability to launch a balloon every 30 minutes supports the assertion that another balloon will float into the area of interest when the first balloon drifts away due to winds, thus continuing, in theory, the communications connectivity. Despite weather forecasting and altitude control, thousands of balloon launches will be required continuously to provide continuous/uninterrupted coverage, and that coverage will only be in specific regions/routes. Loon will have significant coverage issues with strong winds even with a consistent line of balloons playing follow the leader. Payload capability is low. It could be increased but then the balloons will need to get bigger and more expensive and perhaps with a more consistent method of station-keeping.

Stratobus. Stratobus is a stratospheric airship solution in development by Thales Alenia. Stratobus is being designed to fly at 60,000-65,000 ft. and carry a payload of 250 kg for multi-purposed missions that include observation/surveillance, navigation assistance, meteorology and communications. The Stratobus airship is expected to be powered by a combination of a solar array and regenerative fuel cells that would be capable of providing 5 kW to the payload. Although reportedly designed to station-keep at approximately 20 km altitude, Stratobus operations are expected to be limited to lower latitude regions due to limited propulsion and therefore a limited capability to combat strong winds at higher latitudes (max winds speeds < 50 knots). It is expected that the Stratobus design will continue to evolve.

VI. THE COMMUNICATIONS AND BASIC SPECTRUM NEEDS OF THE ELEFANTE GROUP SBCS SYSTEM

As the foregoing discussion makes clear, Elefante Group is proposing that the Commission adopt rules that will permit SBCS systems to be deployed to meet a variety of communications needs and advance numerous Commission and Administration objectives. The sort of system that Elefante Group intends to deploy is a radical departure from previous stratospheric platform projects. A persistent, high capacity SBCS will represent a significant step forward in effective and efficient use of spectrum in the stratosphere, offering services across the range of urban and rural customers, consumer and enterprise services, while supporting the advancement of national objectives in the deployment of 5G services through fast and flexible backhaul and network services across the United States.

As explained below, given the well-documented increasing demand for capacity, the deployment of STRAPS offering 1 Tbps service can provide significant advantages in support of deployment of telecommunications and broadband services to meet that demand. The unique ability to place the large payload capacity needed to support 1 Tbps communications in the stratosphere and station keep is enabled by building a large airship with sufficient power and propulsion to support long mission durations with a range of wind conditions. Smaller STRAPS will have more difficulty to station-keep and provide reliability services given the seasonal change of the winds at 65,000 ft as they cannot lift the combined mass of the power, propulsion and payload.

Market demand for, and flexibility needed to support, the next generation technologies continues to grow exponentially. According to Cisco Systems, Inc., global Internet protocol traffic will triple in the five years between 2016 and 2021 with a cumulative annual growth rate of 24% over those five years, with increasing end user traffic delivered within a metro network,

up from 22% in 2016 to 35% in 2021.[60] Traffic will continue to be condensed within busy hours, with busy hour traffic increasing by a factor of 4.6 between 2016 and 2021 compared to average Internet traffic growth of 3.2 during the same period.[61] Additional capacity supporting residential and enterprise end users within urban and surrounding areas is needed, including support for densification of 4G and growth to 5G networks with rapid, flexible backhaul and networked solutions, including a solution that allows near instantaneous reconfiguration to support demand changes.

Small cell technologies, reflecting the use of higher 5G spectrum, will provide a flexible way for mobile operators to deploy capacity where needed, and to implement effective frequency reuse in small pockets where capacity is required. However, without flexible and already available backhaul, the cost for new backhaul can quickly outstrip the advantages of small cell deployments due to the time and costs of securing rights of way and building out new backhaul networks potentially limiting wider deployment of 5G. A ubiquitous service such as SBCS with accessible capacity across an entire metro area can provide a timely and cost-effective backhaul solution for 4G and 5G small cell solutions. With an SBCS solution, small cell capacity networks can be dropped into the middle of a demand area rather than just where fiber is or will soon be readily available.

The explosion in connected devices will continue unabated. Over 35 billion IoT devices will be connected by 2021, increasing to 75 billion by 2025.[62] Connectivity solutions to support

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60 "The Zettabyte Era: Trends and Analysis," Cisco White Paper at 2 (June 2017), available at https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.html.

61 *See id*.

62 *See* Morelli, Bill, Associate Director, his, "Internet Connected Devices: Evolving from the 'Internet of Things' to the 'Internet of Everything,'" at 10 (2013).

the integration of IoT devices into infrastructure ubiquitously across a service area with a cost-effective backhaul solution will allow rapid development of new applications supporting operational cost savings and faster services across a range of industries and government initiatives.

The Elefante Group SBCS system is designed to provide nearly uniform capacity in each beam to distribute the 1 Tbps bi-directional service across the entire 15,400 km^2 service area to meet the foregoing needs. This is accomplished as a conscious requirement so coverage towards the edge of the service areas, residential suburbs and beyond is nearly proportional to that in an urban core and throughput remains high.[63] In areas where a single STRAPS covers a metropolitan area, or even if multiple STRAPS are required for coverage, coverage will inherently extend into low population density and rural areas.

To achieve the target throughputs of 1 Tbps in both the uplink and downlink directions, Elefante Group needs sufficient spectrum. Large channel sizes will support the design goal of 1 Tbps, with multiple physical channels effectively reused through application of different polarizations and multiple spot beams from the STRAPS. Overall, the Elefante Group STRAPS will utilize three different types of links: STRAPS to UT links, feeder links from STRAPS to a terrestrial IP transit or other ground-based transport, and links between STRAPS.

A. STRAPS-UT Links

For service links between STRAPS and end user locations, Elefante Group is seeking the ability to use large channel sizes to provide high throughputs per beam to support the wide range of applications described in Section IV. Utilizing a commercially available waveform with

[63] In the outer parts of an Elefante Group STRAPS coverage area, beam size will be larger due to the elevation angle, although there will likely be a more than corresponding drop in customer demand for capacity, even in the outer parts of larger markets that may require multiple STRAPS for complete coverage.

select modifications that are allowed in the waveform specification, baseline spectral efficiencies of > 4.5 bps/Hz can be achieved, multiplied across the total number of beams and channel size to produce the overall capacity of the airship. A minimum of 3 GHz of unencumbered Ka-band spectrum is required to achieve the maximum STRAPS designed throughput. However, the reality is that SBCS will not operate in unencumbered spectrum. To achieve 1 Tbps in each direction, operate compatibility with incumbent services, and allow for multiple SBCS providers to operate, Elefante Group, through analysis performed in conjunction with Lockheed Martin, has determined the need for a modest amount of additional spectrum, relatively speaking, for links between STRAPS and UTs. How much more depends on the specifics of the encumbered spectrum at issue. The spectrum plan outlined in Section VII provides for highly efficient spectrum usage. With a modest base waveform spectral efficiency of > 4.5 bps/Hz, the Elefante Group STRAPS being designed allow for channel reuse more than 130 times per STRAPS, producing an effective platform spectral efficiency over 700 bps/Hz with 4.35 GHz of total spectrum. However, overall, despite the increase in total spectrum, the larger amount of spectrum will be effectively utilized because it enables sharing with other existing users.

Elefante Group anticipates that much of the traffic carried by an SBCS will be between UTs in the same market utilizing the payload's advanced switching fabric for the beam-to beam-switching, for example, traffic from a mobile operator 5G small cell backhaul aggregator point can be uplinked to the STRAPS and down linked directly to any point on the network of the same mobile operator.

B. SBCS Feeder Links

Links between Elefante Group STRAPS and E-band ground stations, feeder links that connect to Elefante Group's transit terrestrial nodes will be carrying aggregated traffic of hundreds of Gbps off-setting the need for additional Ka-band spectrum. Fortunately, there is

adequate spectrum for high capacity fixed links in the 71-76 GHz and 81-86 GHz bands, especially because the spectrum can be reused multiple times on each STRAPS to dedicated ground stations within the central portion of the service area. The number of ground stations and ground station links will be determined by the capacities needed by each STRAPS deployment. As noted earlier, traffic on the Elefante Group SBCS can be switched between service links in the Ka band spectrum without having to first be transmitted to and from a ground station (which increases the spectrum efficiency of the Elefante Group system even further). Thus, the number of ground stations requiring feeder links in the Elefante Group SBCS system is minimized by the beam-to-beam switching capability of the Elefante Group STRAPS. On average, Elefante Group expects each STRAPS will require 10-12 feeder links each using the 71-76 and 81-86 GHz bands to satisfy the feeder link requirements.

VII. ELEFANTE GROUP PROPOSES THAT SBCS HAVE ACCESS TO 21.5-23.6 GHZ AND 25.25-27.5 FOR STRAPS-UT LINKS

Elefante Group, based on considerable detailed examination of high-band spectrum, including numerous compatibility studies conducted by Lockheed Martin on its behalf, has concluded that the most suitable spectrum ranges for STRAPS-UT links are 21.5-23.6 GHz (uplink) and 25.25-27.5 GHz (downlink).[64] As explained herein, the choice of this spectrum, selected from more than 26 GHz of spectrum at and above 17 GHz, was influenced by a number of factors. First and foremost, however, since Elefante Group and Lockheed Martin are developing an SBCS that incorporates compatibility by design, is the ability to operate in the presence of the incumbent users, while allowing reasonable opportunity for both the incumbents and SBCS to evolve and expand.

[64] Upon further consideration of study results and other information, Elefante Group and Lockheed Martin continue to study the potential for use of 23.6-24.0 GHz for STRAPS-UT links as ancillary to operations in the 21.5-23.6 GHz band.

A. Factors in Choosing Candidate Spectrum Bands for SBCS STRAPS-UT Links

1. Technical Performance Criteria

The threshold consideration in frequency selection was to ensure that the operational and technical needs of the Elefante Group reference SBCS design would be satisfied. Important system considerations driving the amount of spectrum and where it could be located are the capacity that the SBCS system is capable of yielding per MHz, user terminal aperture size and number of apertures, atmospheric attenuation and weather availability, and channel sizes that could be supported.

a. Amount of Spectrum Required to Achieve 1 Tbps Capacity

Elefante Group and Lockheed Martin concluded that, given the radio technologies that would be available and the implementation of a high degree of frequency reuse, in order to achieve 1 Tbps in each direction for STRAPS-UT links, *in greenfield spectrum*, at least 3 GHz of continuous spectrum would be required. However, because Elefante Group is looking to operate a spectrally compatible system in encumbered spectrum, the actual amount of spectrum would need to be more to allow for additional channels to permit for flexible spectrum access management. Exactly how much more would be the result of compatibility analysis which assessed the availability of the various channels in question. Factors include having alternative bands available to provide service in localized areas where compatibility prevents some bands from being used, flexibility to temporarily adjust bands being used across a service area to prevent transient harmful interference that would otherwise occur, and guard band needs for protection of adjacent and nearby bands from out of band emissions.

b. Minimum and Maximum Frequency

To maximize the ease of residential installation, Elefante Group concluded that UTs, which will be professionally installed, should conform to accepted norms for satellite communications terminals. These would include size and mounting locations already supported by local zoning and community rules. Keeping apertures smaller than 45 cm while maintaining the gain necessary to support uplink and downlink of highly spectrally efficient waveforms set a practical minimum for spectrum at around 17 GHz. Keeping weather losses low enough for practical UTs and power amplifiers to maintain reasonable availability at desired rates set a practical maximum for spectrum at 50 GHz or below.

c. Separation of Uplink and Downlink Bands

Practical user terminals must use a single aperture for cost, ease of installation, and acceptable standards for mounting. This requires all frequencies to be within a small range, both uplink and downlink. If, on the other hand, uplink and downlink bands are separated too far, by say, more than 5 GHz, a common feed (for implementations using reflectors) cannot support both bands and would require more than one aperture. Similarly, uplink and downlink bands that are too wide from top to bottom could have negative SWaP implications due to the need for more than one aperture on the STRAPS.

d. Need for contiguous bandwidth

If the uplink or downlink band is assembled out of discontinuous band fragments, transmitters and receivers become impractical to implement affordably, and high capacity systems are much more difficult, if not nearly impossible, to implement. Considering approaches to efficient use of spectrum for two different SBCS applications further illustrates the problems of disaggregated spectrum for an SBCS system:

- An SBCS system with the objective to provide continuous coverage across a platform service area might use a laydown pattern of overlapping beams each assigned different frequency "colors." For even capacity across the coverage area such a system would divide the band into the minimum number of colors to control self-interference between beams. Without contiguous spectrum, the smallest band available will determine the size of the channels available in the beams, and prevent the most efficient color assignments.

- An alternative system might apply time division multiplexing ("TDM") to cycle the full spectrum available through a similar beam laydown pattern or a smaller number of beams if the service is focused on a finite number of known sites rather than broad coverage. For many waveforms (e.g. DVB-S2x), practical, low cost terminals employing TDM would use a single carrier which would could not be split across bandwidth that is not contiguous.

Discontinuous spectrum will drive up SWaP and the cost of both STRAPS and UT equipment, possibly to a point that is less economically feasible.

e. System Availability Considerations

For applications supporting 5G backhaul and broadband internet, an availability of 3 to 5 nines at some minimum rate is necessary for reliable service. Atmospheric propagation losses from weather (clouds, water vapor, but primarily precipitation) increase markedly with increasing frequency, making lower bands more attractive. For the same availability target, a higher frequency system requires more power and/or margin to overcome the increased weather loss, driving cost, complexity, and mass into the airborne payload and terminals.

Implementation of SBCS at higher frequencies within the range examined, while technically feasible, erodes the business case for SBCS in terms of performance *versus* cost and weight, and at a certain point will make SBCS economically unfeasible. The SWaP trades are simply unacceptable.

f. Service Area Size

A related effect of weather loss increase with higher frequencies is the impact on system coverage area. SBCS geometry necessarily requires that links to UTs further from the STRAPS

will be at longer range and lower elevation, so providing similar quality of service at edge of coverage reasonably comparable to that at the center requires equipment on STRAPS and UTs to overcome both increased range loss and frequency dependent weather losses through lower elevation paths. As with availability, lower frequencies allow a larger coverage area from one STRAPS, while supporting the same coverage at higher frequencies drives cost, complexity, and mass into the airborne payload and terminals.

g. Minimum Channel Bandwidth

Capacity considerations to serve the target markets requires a minimum channel bandwidth. Elefante Group intends to support high channel rates over a large contiguous coverage area, use a beam laydown pattern with the allocated spectrum broken into colors, and reuse the colors more than 130 (and as many as 180) times across the beams within the STRAPS footprint. To achieve 1 Tbps given this system design sets the necessary data rate that must be supported within a single beam, i.e. the maximum data rate the system can provide a single UT, which in turn dictates the bandwidth of the colors allocable to beams.

h. Color Reuse, Compatibility in Encumbered Spectrum, and System Transitions

To achieve the carrier to noise ratio necessary for the high spectral efficiency (> 4.5 bps/Hz) planned for Elefante Group's high throughput SBCS, the contribution of inter-beam interference from beams assigned the same color must be lower than systems with lower spectral efficiency. This means that a minimum number of colors is required. Six to eight colors (three to four bands with polarization diversity) are necessary to prevent inter-beam interference from preventing use of high spectral efficiency waveforms.

Additionally, compatibility with existing services requires that some SBCS beams in certain circumstances be restricted from using colors that would harmfully interfere with or

receive unmitigatable interference from other services. To allow the network resource manager to achieve compatibility through color assignment in encumbered spectrum, as noted above, additional bands beyond the minimum are necessary.

Further, STRAPS must periodically be serviced requiring handover of services between airships without interruption of service. For systems with broad coverage using large beam laydown patterns (such as the Elefante Group system) users on each beam of the outgoing airship must be transferred to beams on the incoming airship. To move users between beams that overlap, a temporary handover band must be available during the small percentage of operational time it takes to effect the transfer.

2. Current Allocations and Incumbent Uses

To select candidate bands for SBCS, in addition to the factors described above, Elefante Group, with the assistance of Lockheed Martin, also examined the uses of the candidate bands between 17-43.5 GHz to see which were the best candidates for compatible operations between SBCS systems and incumbent and proposed uses.[65] The companies examined not only the question of whether the SBCS systems could operate while minimizing the impact on existing deployments but also whether incumbent users would have the ability to modify and grow their systems. At the same time, Elefante Group and Lockheed Martin were interested in finding bands where SBCS systems could not only achieve a reasonable penetration of deployment to meet market demand, but also to provide a high level of service that would meet anticipated performance requirements (taking into account, for example, the factors described above).

[65] Among other things, the companies examined pending rulemakings and petitions in the bands they reviewed.

To the extent feasible, Elefante Group and Lockheed Martin focused their efforts on bands that already have primary or co-primary Fixed Services allocations and in which Fixed Services have been licensed, since SBCS is best described as a Fixed Service as its ground terminals are fixed and its platform is maintained around a nominal fixed point. This was for two reasons. First, to the extent SBCS was limited to existing Fixed Service allocations, minimal changes by the Commission to the Table of Frequency Allocations would be required. Second, and perhaps more important, just as existing Fixed Services are able to use the bands and co-exist with other services in such bands, SBCS would be more likely to find the fixed bands more compatible.

Examining the bands over the range in question, considering both uplink and downlink operation, bands were eliminated based on incumbent uses. Some were allocated to safety of life applications, for example air traffic radar. Some were allocated to incompatible technical approaches or authorization schemes, for example UMFUS, with regional auctions presenting no basis for coordination of SBCS and technical characteristics preventing effective service. Some were allocated to Fixed-Satellite Service, including through NGSO rulemaking, posing, while not theoretically impossible, extremely complicated compatibility requirements. By this process – identifying contiguous bands with the highest potential for compatible uplink and downlink that are close enough in frequency for single aperture UTs and as low in frequency to maximize weather availability and service area – Elefante Group and Lockheed Martin were able to settle on the proposed user bands for further examination and confirmation of compatibility.

B. The Candidate Bands for Platform-to-User Terminals and Justification for Making Available for Stratospheric Platform Communications

Based on the factors discussed in the previous section, the bands that are best suited for Fixed Service SBCS platform-to-UT links, in order to meet the necessary bandwidth

requirements and coexist with incumbent users, are 21.5-23.6 GHz and 25.25-27.5 GHz.[66] Elefante Group proposes that the Commission explicitly authorize SBCS to access these bands as a co-primary Fixed Service. These bands generally already have a primary allocation for Fixed Services or are well-suited for such allocations. In addition, the bands generally do not include rules or licenses for mobile operations which create specific compatibility issues (not only with SBCS but with other incumbent services as well)[67] and have allocations for several passive services with which SBCS can operate compatibly or be no more interfering when compared with other Fixed Services. Further, the 21.5-22 GHz sub-band and the entire 25.25-27.5 GHz band are being considered for a WRC-19 decision that would identify HAPS operations in ITU Region 2, which constitute a subset of SBCS services.[68] Incumbent allocations and uses of these frequency ranges are discussed below in subsections VIII.B.1 and 2. In Section VII.C., Elefante Group summarizes the results of Lockheed Martin's compatibility analyses it has undertaken with each of these incumbent uses.

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66 In this Petition, Elefante Group urges the adoption of rules that would allow SBCS systems to deploy in the 21.5-23.6 and 25.25-27.5 GHz bands, such as Elefante Group's planned system. To achieve that end, Elefante Group proposes SBCS access to the bands identified herein. As a general matter, however, it is certainly possible that licensees in other bands of Fixed or Mobile Services, through rule waiver or changes, might seek to deploy their spectrum on stratospheric platforms as a complement to their ground-based systems. This petition takes no position on and does not seek rules to permit such deployments. Any such consideration of stratospheric deployments in other bands than those that are the subject of this Petition by existing licensees of ground-based systems should be addressed in separate proceedings.

67 The Commission has recognized the general incompatibility of mobile services with fixed services, for example. *See Use of Spectrum Bands above 24 GHz for Mobile Radio Services* et al., GN Docket No. 14-177 et al., Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, FCC 17-152, ¶¶ 193-96 (rel. Nov. 22, 2017) ("*Spectrum Frontiers Second Report & Order*").

68 World Radiocommunication Conference, Final Acts WRC-15, Resolution 160, [at 261-63] (2015). ITU, *World Radiocommunication Conference 2019 (WRC-19) Agenda and Relevant Resolutions*, at 35-36 (rev. Aug. 15, 2017) ("WRC-19") (Agenda Item 1.14), https://www.itu.int/dms_pub/itu-r/oth/14/02/R14020000010001PDFE.pdf.

1. The 21.5-23.6 GHz Band

Elefante Group's SBCS platform-to-UT links, which will be at fixed locations, will operate as a non-Federal Fixed Service. There are already primary Fixed Service allocations between 21.5-23.6 GHz.[69] There is currently no non-Federal primary Fixed Service allocation in the 25.25-27.5 GHz band, but the Commission should allocate the band for that purpose. In addition, although there are primary mobile allocations in the sub-bands of the 21.5-23.6 GHz range, there are no mobile rules or licenses in these bands.[70]

Several of the target sub-bands include co-primary passive services, with which Lockheed Martin and Elefante Group compatibility studies demonstrate SBCS can operate compatibly, or in some cases be no more interfering when compared to existing Fixed Services, as described below in Section VII.C. In the 22.21-22.5 GHz band, there are co-primary non-Federal and Federal allocations for the Earth Exploration Satellite Service (passive) ("EESS"), Radio Astronomy Service ("RAS"), and Space Research Service (passive) ("SRS"). The 22.55-23.15 GHz band also includes a primary allocation for SRS.[71]

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[69] The non-Federal licenses in this band are Part 101 Fixed Microwave licenses. These include Common Carrier Fixed Point to Point Microwave licenses held by phone companies and Internet service providers, Microwave Public Safety Pool licenses held by states and local institutions, and Microwave Industrial/Business Pool licenses held by various enterprises and academic institutions. A variety of Federal government facilities also operate point-to-point microwave radiocommunications links in this band. *See* https://www.ntia.doc.gov/files/ntia/publications/LRSP5c.htm. According to the NTIA Federal Spectrum Use Summary, observations are made in the 18.2-25.2 GHz range for continuum measurements and spectral-line studies.

[70] *See, e.g.*, 47 C.F.R. § 2.106 (21.4-26.0 GHz) FCC Rule Parts include Part 101 Fixed Microwave and Part 25 Satellite Communications).

[71] In the 22.5-22.55 GHz band, while applicants for airborne stations are urged to take all practicable steps to protect RAS observations in the adjacent bands from harmful interference, RAS in this band is protected from unwanted emissions only to the extent that such radiation exceeds the level that would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates. *See* 47 C.F.R. § 2.106, footnotes US211, US74.

The 22.55-23.55 GHz band also includes a primary allocation for the Inter-Satellite Service ("ISS"). Iridium has ISS operations [72] and Audacy has proposed ISS operations[73] within this band. Elefante Group and Lockheed Martin believe Fixed Service SBCS operate compatibly with these systems.[74]

In addition, NASA operates the Tracking and Data Relay Satellite ("TDRS") constellation in the 22.55-23.55 GHz band to provide forward links to Earth orbiting spacecraft.[75] NASA uses the satellites to provide continuous tracking and high-data-rate communications with the International Space Station, the Hubble Space Telescope, launch vehicles, and other spacecraft in low-Earth orbit.[76]

2. The 25.25-27.5 GHz Band

There is currently no non-Federal Fixed Service allocation in the 25.25-27.5 GHz band. There is a primary allocation for Federal Fixed Services throughout this range, indicating the

72 *See Iridium Constellation LLC, Application for Modification of License to Authorize a Second-Generation NGSO MSS Constellation*, Order and Authorization, FCC 16-875 (2016).

73 Application for Satellite Space Station Authorizations of Audacy Corporation, IBFS File No. SAT−LOA−20161115−00117, Attachment "Narrative Exhibit", p. 2 (filed Nov. 15, 2016) (hereinafter "Audacy Application"). *See also*, Comments of Elefante Group on Audacy Application (filed June 26, 2017); Elefante Group Inc. Ex Parte Presentation, File No. SAT-LOA-20161115-00117 (filed May 16, 2018) ("Elefante Group May 16 Ex Parte").

74 *See* Section VII, infra (discussing compatibility with Iridium and Audacy). *See also* Elefante Group May 16 Ex Parte at 3-7. In addition, all Federal and non-Federal allocations in 22.81-22.86 and 23.07-23.12 GHz are subject to footnote US342, which states that, even though there is no allocation for RAS, other services are permitted provided that they have taken "all practicable steps" to "protect the radio astronomy service from harmful interference." US342 further states that "Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service." However, there has been no opposition from RAS to the proposed ISS operations of Iridium and Audacy in the 22.55-23.55 GHz band. Elefante Group will take "all practicable steps" to protect RAS operations in the band.

75 NASA, *NASA Spectrum 20 GHz to 100 GHz*, available at https://www.nasa.gov/directorates/heo/scan/spectrum/txt_NASA_Spectrum_20GHz_to_100GHz.html.

76 David Szondy, New Atlas, *NASA Completes Space Communications Network*, available at https://newatlas.com/nasa-space-communications/50962/.

band is suitable for Fixed Services. Further, the 24.25-27.5 GHz frequency range, [77] in addition to the 21.4-22 GHz band, was identified at WRC-15 for study for possible use by HAPS within the Fixed Services in ITU Region 2.[78] Although Elefante Group's platforms will not fall within the HAPS category due to their operating altitude,[79] HAPS is a subset of SBCS. As reflected in Resolution 160 (WRC-15), there are already international efforts under way that recognize the value of identifying spectrum for stratospheric operations and purposes in this band.[80] Resolution 160 explicitly recognizes the value of nominally fixed airborne platforms for "broadband connectivity… in underserved… and remote areas," that "[airborne platforms] can provide broadband connectivity with minimal ground network infrastructure," and that "[airborne platforms] may also be used for disaster recovery communications."[81] While the U.S. proposal to WRC-19 on agenda item 1.14 for HAPS is not yet formulated, the U.S. within the international community recognizes the value proposition of stratospheric platforms in this band, having noted that airborne platforms have advantages with respect to coverage, cost, reach, deployment time, payload flexibility, and environmental impact.[82]

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77 World Radiocommunication Conference, Final Acts WRC-15, Resolution 160, at 261-63 (2015).

78 World Radiocommunication Conference, Final Acts WRC-15, Resolution 160, p. 1-3 (2015).

79 The Elefante Group platforms are being designed to maintain altitudes *below 20 km* for optimal airship performance and efficiency, taking into account the weather conditions at various altitudes based on the analysis of years of data. For this reason, they fall outside the strict regulatory definition of high altitude platform stations, or HAPS, which specifies stations operating between 20 and 50 km. *See* 47 C.F.R. § 2.1(c) (definition of "High Altitude Platform Stations").

80 In particular, Resolution 160 invited the ITU-R "to study additional spectrum needs for gateway and fixed terminal links for HAPS to provide broadband connectivity in the fixed service." Resolution 160, p. 2.

81 *Id.*, p. 1.

82 US Preliminary View on WRC-19 Agenda Item 1.14, p. 2-3 (Dec. 1, 2017).

In addition to the allocation for Federal Fixed Services, the entire 25.25-27.5 GHz band includes a primary allocation for Federal Mobile Service and Federal ISS. [83] Within this band, Federal uses include Aeronautical Mobile Service ("AMS") Airborne to Ground links and Data Relay System (DRS") Return links (NGSO to GSO). The 25.5-27 GHz band also includes a co-primary allocation for Federal EESS and Federal SRS. In the 25.25-27 GHz band, there are secondary Federal and non-Federal allocations for ISS and standard frequency and time signal-satellite (Earth-to-space).[84] There is a secondary non-Federal ISS allocation in the 27.0-27.5 GHz band.[85]

C. Compatibility Analysis

In the case of each band proposed for SBCS in this Petition, Elefante Group and Lockheed Martin engaged in detailed and in-depth compatibility studies and consideration of any mitigation that might be required. Based on the foregoing factors in Section VII.A. and B, there are only two bands in the range 17 – 43.5 GHz that Lockheed Martin and Elefante Group concluded are realistic candidates that would meet the criteria and enable terabit SBCS service in this country: 21.5 – 23.64 GHz for uplink (UT to STRAP) and 25.25 – 27.5 GHz for downlink (STRAP to UT). In sum, these bands are close enough to each other to allow use of a single aperture appropriately sized for residential installation, have atmospheric attenuation low enough

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[83] The Region 2 allocations for 27.0-27.5 GHz are identical to the Federal allocations, except Region 2 also has a co-primary allocation for the Fixed Satellite Service (Earth-to-space) ("FSS").

[84] The international allocations (both primary and secondary) in this band are identical to the Federal allocations.

[85] Footnote 5.536A, which prohibits administrations operating earth stations in the EESS and/or SRS from claiming protection from stations in the Fixed and Mobile services operated by other administrations. (The international allocations in this band are identical to the Federal allocations, and are also subject to Footnote 5.536A.) This footnote demonstrates the willingness of the international community to make accommodations for Fixed Services in this band.

to practically design for high availability, and are large enough to be allocated into four or more 450 megahertz bandwidth channels. 450 megahertz channels with > 4.5 bps/Hz efficiency permit over 2 Gbps per beam (the limit on an individual UT), and a sufficient number beams per the Elefante Group system design aggregate to over 1 Tbps capacity over a large coverage area.

As explained herein, Elefante Group has integrated the goal of compatibility with incumbent operators in the bands of interest throughout the design and operating capabilities of the STRAPS platform. In design trade-offs, consideration was consistently given to allow sharing to minimize impact to incumbent users. Within these parameters, Lockheed Martin conducted compatibility analyses for SBCS operating in the bands proposed here for SBCS-UT links, including operation of multiple SBCS service providers sharing the band. The compatibility studies indicate that, through the regulatory limits proposed below in Section IX, combined with coordination where required and, in certain instances, mitigation, spectrum sharing can protect existing users, allow incumbent user growth, and permit deployment of SBCS systems, including competitive systems, within STRAPS service areas.

Lockheed Martin conducted compatibility studies with the SBCS radios as potential interferers into identified types of existing users in the target bands. The bands studied, proposed STRAPS usage, study results, and any mitigations necessary to protect incumbent users were identified, including possible limitations on STRAPS parameters or operations where that was required to enable compatibility. Usage of the 22-23 and 26 GHz spectrum bands was analyzed in both the uplink and downlink directions as part of the overall spectrum analysis completed, although, to achieve maximum compatibility, Elefante Group envisions 22-23 GHz as being primarily an SBCS uplink band and 26 GHz as an SBCS downlink band.

In all analyses for a first-step bounding analysis, the worst-case operating conditions for UTs[86] and STRAPS[87] were utilized. In addition, each study sought to identify the worst-case geometry between the incumbent user and the SBCS system, as a starting point for the static scenario. Such worst-case geometries and operating conditions were analyzed regardless of the probability of the worst-case scenario arising. Where the proposed limits for SBCS operations did not ensure compatibility with a static interference protection criterion, the study proceeded to consider statistical analysis methods to evaluate compliance with statistical interference protection criteria for each service[88] or to evaluate likelihood of interference. This conservative approach was pursued given the objective of enabling SBCS to operate in encumbered spectrum as a co-primary service on a truly compatible basis.

Section VII.C. first addresses compatibility studies relative to use of the 22-23 GHz band for UT uplinks[89] and STRAPS downlinks in the 26 GHz band.[90] At the end, studies exploring usage of the 22-23 GHz band for STRAPS downlinks and the 26 GHz band for UT uplinks are summarized.[91] The characteristics of the STRAPS and UTs used in the studies are shown in

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86 For the worst-case operating conditions in the uplink direction, the studies assumed the maximum number of UTs transmitting simultaneously to fully occupy the victim bandwidth, transmission at maximum EIRP which achieves the highest data rates, and no consideration for atmospheric propagation, cross-polarization isolation or ground clutter losses.

87 For the worst-case operating conditions in the downlink direction, the studies assumed the STRAPS was transmitting at a level equal to the maximum power flux density limit as authorized for satellite downlinks into Fixed services and that multiple STRAPS downlink channels were operating simultaneously to ensure that the victim bandwidth was fully occupied. STRAPS were assumed to operate in the same polarization as the victim receiver.

88 In some cases, the interference protection criteria included percentages of time in which the interference threshold would be exceeded. Nonetheless, Lockheed Martin and Elefante Group examined the worst-case static scenario first.

89 *See* sub-section VII.C.1.

90 *See* sub-section VII.C.2.

91 *See* sub-section VII.C.3.

Appendix A. The analyses are identified and briefly summarized below and are detailed in individual Appendices B through U.

1. Studies of UT Uplink Operations in the 21.5-23.6 GHz Band

Elefante Group proposes that SBCS operators be able to access the 21.5 – 23.6 GHz band for SBCS-UT uplinks as a Fixed Service on a co-primary basis. Compatibility studies were conducted to evaluate the spectrum sharing capabilities between SBCS (using the Elefante Group reference design) and existing non-Federal and Federal incumbent uses: non-Federal Fixed Service and ISS links, as well as Federal Aeronautical Mobile Ground-to-Airborne Links, ISS links, EESS Passive sensors, and RAS. The results of the studies confirm Elefante Group's and Lockheed Martin's preliminary conclusions that compatible operations of SBCS uplinks in the 21.5-23.6 GHz range is technically and practically feasible. The results are summarized below and presented in Appendices as noted.

a. Non-Federal Incumbent Uses

i. Fixed Services

Fixed Services (FS) are authorized in the entire range 21.4-23.6 GHz. Lockheed Martin assessed the compatibility of UT uplinks with Fixed Service (FS) point-to-point microwave links. *See* Appendix B. The study demonstrated that UT uplinks would be able to readily coordinate with FS links, and Elefante Group proposes that they do so much as FS links coordinate among themselves today when new links are added. The impact from the SBCS uplinks, because of the geometric diversity in elevation angle, is generally expected to be less than that from potential future conventional fixed links.   As explained in more detail in Section IX, Elefante Group proposes that SBCS licensees, once a STRAPS location is coordinated, engage in pre-coordination to define frequency-dependent protection contours around existing

conventional links.[92] These contours would define locations UTs could not deploy (on the frequencies licensed to the respective traditional FS links), and that as SBCS UT links are added, consistent with those protection contours, they would be registered and added to the Commission's database to allow future coordination of other FS links. Conversely, the construction of new conventional fixed service links might modify the protection contours used by SBCS operators. A proposed streamlined approach for coordination is discussed in Appendix B and in Section IX.E.3 below.

ii. <u>NGSO Inter-Satellite Links (Iridium</u>

Iridium possesses the only non-Federal ISS license in the 23 GHz band, specifically at 23.183 – 23.377 GHz, which is used to crosslink Iridium's low earth orbiting satellites. Lockheed Martin assessed the compatibility of UT uplinks with NGSO ISS links which are authorized to operate in the 22.55-23.55 GHz band, focusing on the worst-case geometry which occurs transiently for UTs located at the edge of the STRAPS coverage area (minimum elevation angle) and an Iridium satellite receiver is co-aligned creating the minimum off-boresight angle to the interferer. *See* Appendix C. The results demonstrate that, even in the worst-case scenario, the NGSO ISS I/N Protection Criteria of less than -16 dB is met and no mitigation is necessary. In real world operations, the conservative assumptions behind the compatibility study and the dynamic nature of the Iridium constellation will ensure that the worst-case geometries are relatively infrequent and short-lived. Therefore, the already compliant and negligible impacts on ISS links would be reduced even further.

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92 *See infra* Section IX.E.3.

iii. MEO-to-LEO ISS Links (Audacy)

Audacy Corporation has a pending application for non-Federal ISS links in the 22.55-23.55 GHz band.[93] Audacy proposes to use the band (with the exception of the frequencies used by Iridium) to crosslink low-earth orbiting ("LEO") satellites of future Audacy customers ("User Satellites") with the proposed medium-Earth orbiting ("MEO") relay satellites of Audacy ("Relay Satellites"). Lockheed Martin endeavored to assess the compatibility of STRAPS User uplinks with Audacy User return links (LEO-to-MEO) and forward links (MEO-to-LEO).

For compatibility with Audacy's User return links, Lockheed Martin studied potential interference into Audacy's Relay Satellites from UT uplinks. *See* Appendix D. Bounding compatibility study indicates the potential for interference, however, such worst-case geometry and operating conditions are unlikely[94] and would be a transient condition. A follow-on risk-based statistical analysis and/or coordination will be conducted to confirm that the LEO-to-MEO ISS service is not impacted on a case-by-case basis and requires additional knowledge of the Audacy's User systems not present in currently available filings.

For compatibility with Audacy's User forward links, Lockheed Martin considered potential interference into Audacy's User Satellites from UT uplinks. Unfortunately, the Audacy application filing for its Relay Satellites contains insufficient information regarding expected third-party User Satellite characteristics, and Elefante Group has requested the Commission

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93 *See* Audacy Application, *supra* note 73. The Application is expected to be considered at the Commission's June 7, 2018, Open Meeting.

94 Per Audacy's *ex parte* submission dated October 13, 2017, Relays will not continuously radiate the Earth's surface. *See* Notice of *Ex Parte* Communication – Audacy Corporation, File No. SAT-LOA-20161115-00117 (Oct. 13, 2017). Statistically, most network user satellites are at the poles and around the edge of the Earth: most Relay-User beams will not intersect Earth, Relay beams only transmit/receive when User present, in-line geometries with Fixed/ Mobile Systems are rare and extremely transient. Likelihood of interference is also dependent on worst-case combination of bandwidth overlap, intersection of STRAPS coverage area with Audacy's MEO satellite beams and transient overlap time between the Audacy's User satellite transmitting and UTs transmitting.

consider the need to impose interference protection criteria to establish certainty both for the designers and operators of the User Satellites as well as Fixed Service licensees.[95]

b. Federal Incumbent Uses

i. <u>Federal Aeronautical Mobile Ground-to-Airborne Links</u>

Compatibility of UT uplinks with Federal Aeronautical Mobile Ground-to-Airborne links in the 22.55–23.55 GHz band was examined. *See* Appendix E. Since the possible locations of Federal Aeronautical Ground stations are not known, a bounding compatibility study was performed to determine the altitude and relative location of the Airborne receiver where there is any possibility of interference. The bounding compatibility study results show that AMS I/N Protection Criterion is met if the aircraft is outside the cone defined by the STRAPS nominally fixed location and the 70 km radius of the STRAPS coverage area. Transient interference might be noticed otherwise. Elefante Group expects that any small chance for interference can be adequately mitigated by coordination which may include UTs not using frequencies or polarization which overlap with the Aeronautical Mobile channel.

ii. <u>Federal ISS Links</u>

NASA's ISS Data Relay System ("DRS"), also known as the Tracking and Data Relay Satellite System ("TDRSS"), operates Forward links (GSO-to-LEO) in the 22.55–23.55 GHz band. Lockheed Martin assessed the compatibility of UT uplinks with these ISS links. *See* Appendix F. The bounding study examined several cases of LEO satellite altitudes to determine

[95] *See* Elefante Group May 16 *Ex Parte*.

worst-case geometries for purposes of possible interference from enterprise and consumer UTs.[96] For all cases except one, even the worst-case transient geometric alignment showed positive margin against the DRS I/N Protection Criterion. For the remaining case, since the interference protection criteria are defined in statistical terms, Lockheed Martin proceeded to perform a risk-based statistical analysis using a 30-day time domain simulation. Results show that the worst-case geometry is an unlikely and transient condition, and the DRS I/N and percentage exceedance time Protection Criteria are met even after assuming worst-case operating conditions. No mitigation is necessary.

iii. <u>EESS Passive Sensors</u>

Allocations exist for EESS Passive sensors to operate in the 21.2-21.4, 22.21-22.5, and 23.6-24 GHz bands. Lockheed Martin assessed the compatibility of UT uplinks with those sensors. *See* Appendix G. Worst-case geometry was analyzed for a single STRAPS-UT, and an unrealistically extreme bounding case was also considered with worst-case geometry from *thousands* of STRAPS-UTs. Bounding compatibility study results were positive. The study results revealed that that conservative regulatory bounds on EIRP in the EESS bands would leave sufficient room for practical UT design, even to meet the interference criterion even in the worst case conditions. Moreover, because the protection criteria are statistical, higher UT EIRPs for specific SBCS implementations would be possible while still meeting the criteria. Analysis also indicates that an active protection approach can permit in-band use of the 22.21-22.5 GHz band for UT uplink with negligible impact to EESS sensors.[97]

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[96] In brief, the worst-case geometries occur when the STRAPS, DRS LEO satellite and DRS GSO satellite are perfectly aligned and, therefore, result in the maximum level of interference.

[97] Notably, under US532, EESS in the 22 GHz band is not entitled to protection from fixed service systems operating consistent with the Table of Frequency Allocations. *See* 47 C.F.R. § 2.106, US532. Nonetheless, rather than relying on the strict application of US532, Elefante

iv. Radio Astronomy Service ("RAS")

The RAS service is allocated in the 22.01-22.21, 22.21-22.5, 22.81-22.86, and 23.07-23.12 GHz, as well as the adjacent 23.6-24 GHz bands. Lockheed Martin assessed the potential for interference into the band from UT uplinks, specifically UT side lobes into nearby RAS antennas. *See* Appendix H. The results of the bounding analysis show that UTs operating in RAS bands must have line-of-sight blockage to not present harmful interference and that separations distances can be reasonably expected to range between 10 and 50 km depending on terminal heights and local topography. Further, UTs operating out of band must have sufficient out of band emission attenuation to be compatible, on the order of 50-70 dB (a technically feasible value) from their maximum permitted EIRP density. Coordination should be conducted between UTs and individual RAS sites based on their unique topography to establish contour maps of maximum permissible UT height to prevent line of sight interference paths to RAS antennas. Elefante Group and Lockheed Martin are in constructive discussion with the National Science Foundation regarding these matters.

2. Studies of SBCS Proposed Operations in the 25.25-27.5 GHz Band

Elefante Group and Lockheed Martin have examined SBCS access to the 25.25-27.5 GHz band for STRAPS downlinks as a Fixed Service on a co-primary basis. Compatibility studies were conducted to evaluate the spectrum sharing capabilities between SBCS (using the Elefante Group reference design) and existing Federal incumbent uses: Aeronautical Mobile Airborne-to-Ground Links, ISS return links, EESS and SRS downlinks, and RAS. While a study was not completed regarding Federal fixed links, Elefante Group proposes that an elevation dependent

Group is pursuing an approach of ensuring that interference to these incumbent users is not more extensive than that which EESS operations are already subjected to from other fixed services stations.

power flux density limit used by satellites and described in 47 C.F.R. §25.208(c) be adopted by SBCS downlinks in the 26 GHz Band to afford the same protection fixed service enjoys from other overhead services when co-primary in nearby spectrum bands. There are no current non-Federal incumbent uses.[98] The results are summarized below and are presented in Appendices as noted.

a. Federal Incumbent Uses

i. Federal Aeronautical Mobile Airborne-to-Ground Links

Compatibility of STRAPS downlinks with Federal Aeronautical Mobile Service Airborne-to-Ground links which operate in the 25.25–27.5 GHz band was examined. *See* Appendix I. The bounding compatibility study assumed that Aeronautical Ground stations could be located anywhere including at the worst-case interference location in the center of a STRAPS system coverage area. Bounding compatibility study results show that AMS I/N Protection Criterion is met for >99% of the field-of-view of the Aeronautical Ground receiver even under

98 The mobile industry has pressed for consideration of the 26 GHz band for commercial mobile operations, and the Commission will be considering adopted a rulemaking to consider making the band available for flexible mobile and fixed use. *See, e.g.*, CTIA Ex Parte Presentation, GN Docket No. 14-177, IB Docket Nos. 15-256, 97-95, WT Docket No. 10-112,, AU Docket No. 18-85 at 2 (May 24, 2018); *see also Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, GN Docket No. 14-177, *Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 to Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services*, WT Docket No. 10-112, Draft Third Report and Order, Memorandum Opinion and Order, and Third Further Notice of Proposed Rulemaking, FCC-CIRC1806-01, ¶ 76 (May 17, 2018). Elefante Group and Lockheed Martin have done an initial assessment of the prospects for sharing between SBCS and mobile operations and believe that IMT cannot share the spectrum without causing unacceptable interference or imposing unreasonable constraints on SBCS operations and, quite possibly, on Federal incumbent band users. Elefante Group and Lockheed Martin remain open to examine the feasibility of such sharing pursuant to advanced mitigation techniques, such as extremely high degree of dynamic coordination and information sharing.

worst-case conditions. Therefore, the likelihood of harmful interference is minimal. No mitigation is recommended.

ii. Federal ISS links

Lockheed Martin examined the compatibility of STRAPS downlinks with DRS Return links (LEO to DRS GSO) operating in the 26 GHz band. *See* Appendix J. Bounding compatibility study results using worst-case operating conditions and interference geometry[99] show that DRS I/N Protection Criterion is met with greater than 33 dB of margin. No mitigation or risk-based analysis is necessary.

iii. EESS Downlinks

Compatibility studies were performed of STRAPS downlink interference into EESS (Space-to-Earth) link operating in the 25.5–27.0 GHz band. *See* Appendix K. Despite using the worst-case operating conditions, the study results show that for a given EESS GSO mission, STRAPS positioned near the associated EESS Earth Station can be easily located to ensure that the EESS Interference Thresholds are met while still serving the intended core market location. For all EESS NGSO systems examined, the EESS Interference Threshold criterion was met for all placements of STRAPS and no mitigation is required.

iv. SRS Downlinks

The SRS (Space-to-Earth) operates in the 25.5–27.0 GHz band. Elefante Group asked Lockheed Martin to conduct an assessment of potential interference from STRAPS downlinks into SRS downlinks. *See* Appendix L. The resulting bounding analysis assumed worst-case operating conditions and interference geometry.[100] In addition, due to the nature of the SRS

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[99] In general, the worst-case geometries occur when the STRAPS, DRS LEO satellite and DRS GSO satellite are perfectly aligned to result in the maximum level of interference.

[100] In brief, the worst-case geometries occur when the STRAPS, SRS satellite and SRS Earth Station (ES) are perfectly aligned so as to result in the maximum level of interference

protection criteria, the study undertook a risk-based statistical analysis. Analysis of the results show that, for a given SRS mission, if required, a STRAPS can easily be placed to ensure that SRS I/N Protection Criteria are met without cognizably compromising its coverage.

v. Radio Astronomy Service

The RAS operates in 23.6-24 GHz separated by 1.25 gigahertz from STRAPS downlink band. Lockheed Martin examined the compatibility of STRAPS downlink out-of-band emissions with RAS. *See* Appendix M. As with the other studies, worst-case operating conditions and interference geometry were considered for a bounding analysis. The study results show the protection criteria were easily satisfied and compatibility is achieved.

3. Studies Related to Prospective Use of the 22-23 GHz Band for STRAPS Downlinks and the 26 GHz Band for UT Uplinks

While Elefante Group's primary proposal in this Petition is that 21.5-23.6 and 25.25-27.5 GHz be made available for SBCS uplinks and downlinks, respectively, the Commission should also consider making these bands available for SBCS links in the opposite direction. In support of that request, Elefante Group provides compatibility studies performed by Lockheed Martin that consider those scenarios.

More specifically, in the 22-23 GHz band, studies were conducted on the same worst-case conditions described above assessing the compatibility STRAPS-to-UT links with co-channel Federal Aeronautical Mobile Ground-to-Airborne links[101] and ISS DRS Forward

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101 *See* Appendix N. The bounding study results show that the AMS I/N Protection Criterion is met under all conditions except during transient and unlikely conditions when the aircraft passes close to STRAPS slightly outside of the FAA recommended keep out zones. Because the likelihood of harmful interference is minimal, Elefante Group has concluded that no mitigation would be required to protect the Aeronautical Mobile communications from STRAPS downlinks in the 22-23 GHz Band.

links.[102] The results again support a conclusion that compatible SBCS operations with these services can be expected.

While no study was undertaken, Elefante Group and Lockheed Martin also evaluated compatibility of SBCS downlinks with non-Federal Fixed services operating in the 22-23 GHz Band. As described below, Elefante Group proposes that the elevation dependent power flux density limit used by satellites and described in 47 C.F.R. § 25.208(c) be adopted in SBCS rules to afford the same protection Fixed service enjoys from other overhead services in Ka Band frequencies when co-primary.[103]

Further, in the 26 GHz Band, studies were conducted (again assuming worst-case operating conditions and geometries) evaluating the compatibility of UT-to-STRAPS uplinks with Federal Airborne-to-Ground links,[104] DRS Return links (LEO-to-DRS GSO),[105] EESS

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102 *See* Appendix O. The worst-case geometry for this study assumed perfectly aligned and located satellites and STRAPS to result in the maximum level of interference. The bounding study showed that even during these transient short-lived condition of worst case perfect alignment of the STRAPS, DRS LEO satellite, and DRS GSO satellite, the DRS I/N Protection Criterion is met. As with the uplink scenario analyzed in Appendix F, no mitigation is necessary to prevent harmful interference into the TDRSS system.

103 *See infra* Section IX.F.

104 *See* Appendix P. The bounding compatibility study shows that AMS I/N Protection Criterion is met unless the victim Ground receiver is located very close to and pointed directly at a UT, and subject to side lobe interference. In such rare instances where harmful interference occurs, Elefante Group is confident that interference can be mitigated via coordination by ensuring that any few offending UTs avoid use of overlapping frequencies/polarization.

105 *See* Appendix Q. Compatibility study results using risk-based statistical analysis show that DRS I/N and percentage exceedance time Protection Criteria are met under worst-case operating conditions. No mitigation is necessary.

(Space-to-Earth) links at 25.5–27.0 GHz,[106] and SRS (Space-to-Earth) links.[107]

D. Spectrum Sharing with Other SBCS

In addition to examining compatibility with existing incumbent users, Elefante Group and Lockheed Martin also evaluated the potential for two SBCS systems to share the same frequencies and serve the same geographic area.[108] Spectrum sharing between multiple SBCS systems is very similar to sharing between geostationary satellite orbit ("GSO") Fixed Satellite Service ("FSS") networks. In both cases, the overhead platform is station-kept around a nominal location, and terrestrial user terminals are pointed at them. Uplink and downlink interference mitigation relies on sufficient separation of the platforms and sufficiently directive antennas on the ground, both of which can be regulated so other systems are protected and the technical criteria for those expecting protection are clear. Critically, in both cases multiple systems can serve UTs located in relatively close proximity on the same frequencies.

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106 *See* Appendix R. The bounding compatibility study results show that ensuring a minimum separation distance between UTs and EESS Earth Stations ("ES") will ensure that the EESS Interference Threshold is met even under worst-case pointing assumptions, i.e., UTs pointing directly at the EESS ES boresight. Further, considering the relatively few locations of EESS ES's in the 26 GHz band and their general location away from highly populated areas, it is very unlikely that a UT would be located close to and pointed at the EESS ES boresight However in such cases, Elefante Group is confident that the Protection Criteria can be met by coordination.

107 *See* Appendix S. The Bounding Compatibility Study demonstrates that, even under worst-case pointing assumptions, i.e., UTs pointing directly at the SRS ES boresight, as little as a 2.2 km separation distance between the UTs and SRS ES would ensure that SRS Protection Criteria are met. Fortunately, there are relatively few SRS stations and they are generally in remote locations. Thus, it is highly unlikely that a UT would be located in close proximity to one and pointed at the SRS ES boresight. Nonetheless in such cases, Elefante Group is comfortable that the protection criteria can be met by coordination.

108 Compatibility analyses for sharing of spectrum between multiple SBCS operators was not conducted in both uplink and downlink in all bands. It is expected that SBCS operators would coordinate use of spectrum in the uplink and downlink directions to optimize performance and prevent mutual interference.

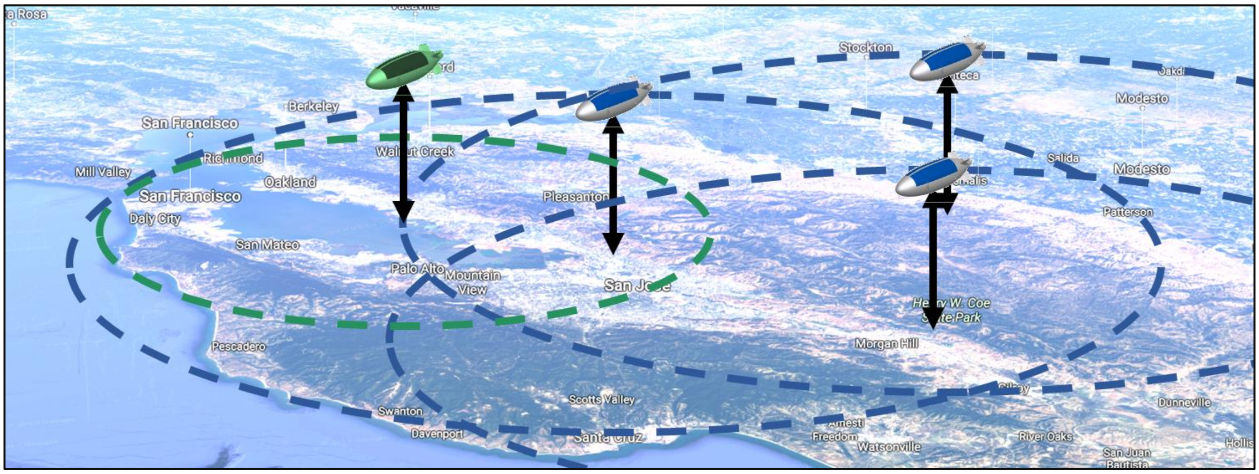

Figure 4: Different SBCS systems with different STRAPS and UT characteristics conforming to proposed rules can have overlapping coverage preventing mutual exclusivity

The geometry for potential STRAPS to STRAPS interference is shown in Figure 4. Uplink interference is determined by EIRP density presented from interfering UTs toward victim STRAPS, which is a function of directivity of the UT antenna, maximum permitted EIRP density, and the off-boresite angle between the STRAPS. Downlink interference is determined by the power flux density accepted by victim UTs from an interfering STRAPS, a function of the incident PFD, directivity of the victim UT, and angle between the STRAPS.

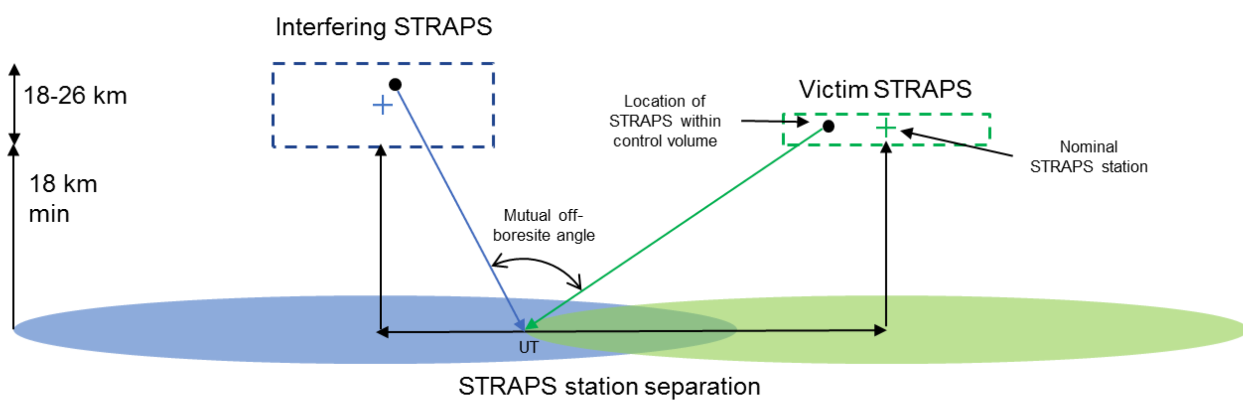

Figure 5: Interference Geometry (not to scale). STRAPS operate within authorized control volume centered on their nominal fixed location. UTs track their assigned STRAPS.

Interference between SBCS systems is primarily dependent on the mutual off-boresight angle for both uplink and downlink interference.

As derived and documented in detail in the attached compatibility studies, *see* Appendices T-U, significant overlap is possible between STRAPS service areas for a variety of possible SBCS systems that conform to the proposed rules. In the studies, cases for interferer and victims systems spanned different UT characteristics, different station altitudes and control volumes, different STRAPS beam characteristics, and different service area radii. The bounding minimum service area overlap ranged from 61% to 75% for no potential for harmful uplink interference, and from 47% to 59% for no potential for harmful downlink interference. Importantly, these are bounding values and a risk based approach or other options available to parties through coordination can further increase this already large overlap.

VIII. SBCS USE OF 71-76 GHz AND 81-86 GHZ AS FEEDER LINK SPECTRUM

The 71-76 GHz and 81-86 GHz ("70/80 GHz") bands are suitable for high-capacity SBCS feeder links with ground stations for connections to terrestrial networks, where such connectivity is required.[109] Such fixed links should be licensed and coordinated largely in the same manner as ground-based fixed links are licensed and coordinated in the band today under the existing Part 101 rules.

A. Allocations in the E-Band

The 70/80 GHz bands are allocated to non-Federal and Federal users for Fixed Services on a co-primary basis.[110] The Commission created a two-pronged authorization scheme for non-Federal users in such bands. First, a licensee applies for a non-exclusive nationwide license.

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[109] The Ka-Band spectrum identified for STRAPS-UT links could also be used as feeder link spectrum by an SBCS operator, depending on its system design.

[110] Per US389, in both of these bands, non-Federal operations may not cause harmful interference to, nor claim protection from, Federal FSS operations located at 28 military bases.

Second, the licensee registers individual point-to-point links. Licensees may operate a link only after registering it with a third-party database and coordinating with NTIA.[111] As of May 18, 2018, there were 477 non-exclusive nationwide licenses in the 70/80 GHz bands operated Part 101 Fixed Microwave devices.[112]

The 71-76 GHz band also has co-primary non-Federal and Federal allocations for FSS and Mobile operations although no such non-Federal operations are currently authorized, and there are no corresponding Commission Rules in place or proposed. Indeed, in the *Spectrum Frontiers Second Report and Order*, the Commission declined to move in the direction of authorizing mobile or satellite operations (or increasing unlicensed access) in the band, as well as the 81-86 GHz band.[113]

The 71-74 GHz sub-band is allocated for Federal and non-Federal MSS (space-to-Earth) operations, and the 74-76 GHz band also has a co-primary non-Federal and Federal allocation for SRS operations. In addition, there are non-Federal allocations in that band segment for

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111 *See Wireless Telecommunications Bureau Announces Permanent Process for Registering Links in the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Public Notice, FCC 05-311 (2005).

112 These statistics are based on a review of the Universal Licensing System on May 18, 2018.

113 *See Spectrum Frontiers Second Report & Order*, ¶¶ 197-201 ("We decline to authorize mobile use in the 70 GHz and 80 GHz bands under UMFUS rules at this time. There is…little consensus among the proponents of mobile use as to how to coexist with fixed links."). Pursuant to Resolution 238 from WRC-15, there are sharing and compatibility studies under way that will be considered under Agenda Item 1.13 at WRC-19, wherein there will be assessment of whether to identify the 70/80 GHz bands for IMT operations. *See* World Radiocommunication Conference (WRC-15), Resolution 238, at 3 (Geneva, Switzerland 2015). Furthermore, earlier this year, the Fixed Wireless Communications Coalition ("FWCC") requested that the Commission adopt several requests with respect to the 71-76 GHz and 81-86 GHz sub-bands. *See* Letter from Cheng-Yi Liu, Counsel for FWCC, to Marlene Dortch, Secretary, FCC, Notice of Ex Parte Communication, GN Docket No. 14-177, IB Docket No. 15-256, RM-11664, WT Docket No. 10-112, IB Docket No. 97-95, at 2 (filed Feb. 13, 2018) (requesting authorization for smaller antennas, 45° polarization, prevention of never-built links accumulating in the registration database, and adoption of a channel plan).

Broadcasting and BSS operations. No non-Federal satellite systems have been authorized pursuant to the allocations, and the Commission has not adopted rules.

The 81-86 GHz band also includes co-primary non-Federal and Federal allocations for FSS (Earth-to-space) and Mobile.[114] The 81-84 GHz band also has a co-primary non-Federal and Federal allocation for MSS (Earth-to-space).[115]

No non-Federal systems other than Fixed Services have been authorized pursuant to the allocations in the 81-86 GHz band nor are there rules in place or proposed to do so.

B. Compatibility Considerations in E-Band

The primary compatibility consideration in both the 70/80 GHz bands is the currently authorized fixed wireless use for point-to-point links, and RAS in the 81-86 GHz uplink band only. By largely conforming with the existing rules within Part 101 for fixed microwave links, as proposed herein for these bands, SBCS can readily achieve compatibility with both services.

In the case of fixed services, the feeder links are simply point-to-point links with high elevation angles. Given the particularly narrow beamwidths in these bands reducing the range of geometries for harmful interference compared to lower bands, the Commission has authorized a registration approach in which compatibility analyses are conducted, documented and filed as part of registration through a third-party database with authorization requiring only NTIA review, rather than pre-coordinated with other licensees over a large area followed by a formal

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114 In the 81-86 GHz band, US161, which designates exclusion zones relative to certain observatories, applies, as does US342, which states that "all practicable steps shall be taken" to protect the radio astronomy service from harmful interference.

115 All Federal and non-Federal allocations in the 81-86 GHz band are subject to US342, which states that "all practicable steps shall be taken to protect the radio astronomy service from harmful interference." US342 further states that "Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service."

application process. Feeder links with overhead geometry as presented by SBCS in either direction are entirely consistent with and can be accommodated naturally by this framework.

High elevation angle uplinks will present only far sidelobes toward terrestrial receivers, greatly reducing the potential range of harmful interference compared to low elevation transmitters, which necessarily project their main lobe horizontally. Feeder downlinks from the STRAPS to gateways will project a very tight beam footprint, and low elevation receivers will benefit from tremendous spatial isolation, receiving interference far into their side lobes and greatly attenuated from their boresight direction.

In the case of RAS the same argument holds to ensure compatibility. High elevation angle transmitters will present dramatically lower EIRP toward RAS sites than low elevation transmitters, and coordination with RAS sites will require less separation distance.

Elefante Group and Lockheed Martin have also considered out of band emissions into the RAS allocations in the 76-81 GHz band, and EESS passive sensing in the 86-92 GHz band. In the case of RAS, out of band emissions from a 71-76 GHz feeder downlink band can potentially present interference to observations in the 76-81 GHz band. Analysis will be conducted on a site by site basis using the same approach applied to compatibility between the 25.25-27.5 GHz user downlink and the 23.6-24 GHz RAS band, to allow coordination.[116] A threshold for PFD at the RAS site *versus* elevation angle of the STRAPS will determine when coordination would be

116 Studies of SBCS user band compatibility with RAS indicate that user band uplinks in the 22.21-22.5 GHz band are the limiting factor as they require there be no line of sight between UTs and the RAS site and therefore some separation between the RAS site and the service area perimeter. Because most of the sites observing in the 76-81 GHz band also observe in the 22.21-22.5 GHz band, it is likely the lower 21.5-23.6 GHz SBCS user uplink band will require a larger separation than will the feeder downlink.

appropriate.[117]

In the case of EESS passive sensing, out-of-band emissions from the 81-86 GHz feeder uplink band could potentially present interference to a variety of operational sensors performing critical meteorological observations in the 86-92 GHz band. A regulatory limit on SBCS EIRP density within the passive sensing band should be established using the same procedure applied to out of band interference from the STRAPS-UT uplink band into the 23.6-24 GHz EESS passive sensing band.[118]

IX. PROPOSED SBCS REGULATORY FRAMEWORK IN THE KA AND E-BANDS

Because Elefante Group and other SBCS operators will be investing in the design, development, and deployment of an innovative and novel service – one that is essential for the full realization of the potential of next generation networks and technologies in this country – the Commission's applicable rules should ensure certainty while promoting flexibility. Rules governing SBCS should articulate the ground rules for licensing and compatible operations of SBCS operators and coordination with incumbents and other SBCS operators.

In this Section, Elefante Group describes the regulatory framework that it believes would achieve these objectives and allow SBCS to flourish. As a general matter, SBCS should be regulated as a Fixed Service under Part 101 of the Commission's Rules. Rule amendments required include changes to the U.S. Table of Frequency Allocations in the Ka-Band (*see* Section

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[117] Additionally, data on STRAPS locations and feeder downlinks will be available through their respective registration databases for use in detailed interference analysis for planning radio astronomy observations.

[118] *See* Appendix G. The protection criteria for the two bands per ITU-R RS.1029-2 in terms of maximum interference and % time exceedable (0.01%) are nearly identical. A regulatory limit on aggregate SBCS EIRP density per STRAPS within a 100 MHz reference band in the 86-92 GHz band can be determined by a bounding analysis (static, worst case geometry disregarding % time exceedable) using all sensors described in ITU-R RS.1861 Table 19. Relief from the level can be sought by a statistical or other showing from the SBCS operator that higher feeder EIRP density values meet the % time criterion.

2.106 of the Commission's rules*)*, bounding SBCS technical and operating parameters that should be codified in the rules to promote compatibility, coordination obligations, and a framework for licensing.

A. Definition of SBCS

As noted earlier, SBCS includes but is not limited to HAPS-like operations. SBCS may be deployed in the stratosphere below 20 km, as Elefante Group plans to do. Elefante Group proposes that the Commission adopt a rule defining SBCS as a Fixed Service providing for communications between STRAPS operating between 18-26 km altitude at nominally fixed positions and fixed UTs.

To qualify as SBCS, STRAPS should be required to station keep within 10 km and, for compatibility purposes, should be limited to a service area of 70 km radius for communications purposes, so as to inherently require a minimum elevation angle that maintains sufficient geometric diversity with both ground-based and satellite incumbents to make compatible operations more likely and the operating environment more predictable, within certain bounds, for other incumbent users.

B. Permitted Services

To derive the full potential benefit of SBCS, there should not be service restrictions on the eligibility to hold an SBCS license. Entities that wish to provide common or private carrier fixed communications, at their discretion should be eligible. Further, SBCS licensees should be permitted to provide either retail or wholesale service, or a combination of both. In addition, SBCS should include communications between STRAPS. However, in order maximize compatibility of SBCS with other services, and provide greater certainty for existing users other operating environment, STRAPS should only be authorized to communicate with UTs and with feeder links while the STRAPS is at its nominally fixed position (i.e., not while en route).

C. Eligibility of Licensees

Licensees should have to certify that they are technically qualified to operate STRAPS. Operators should be required to hold and, upon request by the Federal Aviation Administration ("FAA") or the Commission, produce any necessary authorization from the FAA to pilot STRAPS. Finally, SBCS licensees must be limited to deploying STRAPS that have received the necessary airworthiness certification from the FAA.

D. Spectrum Bands for STRAPS-UT Links

STRAPS-UT links for SBCS should be authorized in the 21.5-23.6 GHz and 25.25-27.5 GHz bands, which Section 101.147 of the Commission's rules should be modified accordingly.[119] Elefante Group proposes that the Commission explicitly authorize SBCS to access these bands as a co-primary Fixed Service. In 25.25-27.5 GHz, amendments to the U.S. Table of Frequency Allocations will be required to authorized Fixed Services, or more specifically SBCS, because there are not currently non-Federal fixed allocations in those bands. This allocation should be made on a co-primary basis, and limitations to SBCS should be accomplished through footnotes. In addition, corresponding changes should be made in Section 101.101 of the Commission's Rules.

E. Licensing of STRAPS and UT Stations in the Ka-Band

1. Geographic Non-Exclusive Licensing

Elefante Group proposes that SBCS licensees receive large regional non-exclusive geographic authorizations over the entire range of frequencies designated for SBCS operations,

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119 As mentioned earlier, Elefante Group and Lockheed Martin continue to evaluate the potential for use of 23.6-24.0 GHz for STRAPS-UT links as ancillary to operations in the 21.5-23.6 GHz band. Access to that band would provide SBCS licensees with more flexibility when seeking to operate on a compatible basis with other incumbent uses by making available, depending upon the system design and needs, an additional channel or more.

as proposed herein. Large area licenses combined with coordination obligations as described below will afford licensees flexibility to operate compatibly with the variety of incumbent users in these bands and in a potentially changing environment that may include the introduction of other SBCS licensees serving the same markets.[120] Elefante Group proposes licensing over Regional Economic Areas ("REAs"), of which there are six in the continental U.S., and three outside of CONUS. Non-exclusive licensing within an REA would provide a certain signal to other SBCS operators where STRAPS deployments might take place without prematurely signaling the business intentions of a SBCS operator to competitor prematurely. Given the large size of a STRAPS footprint at SBCS operating altitudes, smaller license areas might restrict the flexibility SBCS licensees' deployments.

2. Consideration of Rural Commitments

As described elsewhere in this Petition, Elefante Group STRAPS deployments positioned over urban areas, in almost all cases, will inherently cover not only the core urban areas, but rural and other low-density population areas as well. Elefante Group expects that as its SBCS business becomes established, its deployments will become more rural in nature by taking advantage of increasing scale and lowered costs of STRAPS construction, deployment, equipment, and ongoing operations. Specifically, Elefante Group intends to deploy in regions surrounding its initial STRAPS coverage areas, as well as in smaller new markets, such that STRAPS service footprints would cover even higher percentages of rural and low-population territory. Other SBCS providers may choose to specifically make rural deployments at the

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[120] Nationwide licensing, given the centrality of registering STRAPS deployments and SBCS-UT links prior to deployment under the proposed regulatory framework, as described below, might be acceptable as an alternative, depending on other rules, such as any bringing to use requirements. However, as described below, Elefante Group proposes bringing into use requirements that are tied to and triggered by, the registration of a coordinated STRAPS at a nominally fixed location and, subsequently, registration of SBCS-UT links.

outset. For the foregoing reasons, Elefante Group is not proposing in this Petition that specific rural regulatory commitments be implemented while SBCS operators are establishing themselves following adoption of SBCS rules.

3. STRAPS and UT Link Coordination and Registration

An SBCS licensee should have the ability to deploy an unlimited number of STRAPS on a non-exclusive basis within the applicable REA subject to advance coordination and registration obligations. Before an SBCS licensee can deploy and operate STRAPS and UT links, the licensee must coordinate the STRAPS at the desired nominally fixed location with existing Federal users in the 26 GHz Band (25.25-27.5 GHz) to the extent they are not already protected from harmful interference by SBCS technical rules.[121] In addition, at the same time as, or after, the STRAPS is coordinated in the 26 GHz band, the SBCS licensee must engage in pre-coordination of UT links in the 21.5-23.6 GHz band.

a. STRAPS Coordination

Within the 26 GHz band there are currently no non-Federal users. As discussed in Section VII.C. of this Petition, the technical limits proposed herein for STRAPS (downlink) operations will be sufficient to protect most if not all co-band Federal ISS, EESS, and SRS operations, as well as federal fixed uses, Elefante Group expects, in the 26 GHz Band. Coordination must be completed by the SBCS licensee with co-band Federal AMS operations, any other SBCS STRAPS already coordinated and/or deployed in the same area with overlapping service areas, and for some RAS facilities in nearby band (23.6-24.0 GHz) operations that are not satisfied by the basic protection requirements described in the Operational and Technical Rules section of this Petition above. Once coordination is complete, the licensee

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[121] *See infra* Section IX (discussing proposed technical rules with aim of maximizing compatibility with other SBCS and other existing users)

registers the STRAPS at the nominally fixed location with the Commission. A STRAPS coordination should remain effective a finite period, during which a timetable for deployment would run. In other words, once STRAPS are registered, they should be subject to bringing into use (and discontinuance) requirements, such as those generally applicable to the wireless services. This will avoid a registered but, after a certain period, not-deployed STRAPS from precluding other SBCS operators indefinitely from deploying in the same, or effectively the same nominally fixed position.

b. STRAPS-STRAPS Coordination

Two SBCS licensees, one with an existing STRAPS and the other planned in overlapping areas, should be required to pre-coordinate their systems with each other in both directions when the SBCS licensee planning the later STRAPS to be deployed notifies the existing STRAPS operator of its intentions. This would trigger a good faith coordination requirement between the licensees. The UT links of one SBCS would be in the same direction – uplink or downlink – as the other in a given SBCS band. Thus, the UT links connecting to one STRAPS could only theoretically interfere with the receive beams on a different STRAPS, rather than with the signals received by a nearby UT. Elefante Group envisions that, using the characteristics of each systems' STRAPS and UTs, the licensees will work out a separation distance of their nominally fixed positions during coordination so their links in both directions can never interfere with each other. A third or later STRAPS deployment serving an overlapping area would be coordinated in a similar fashion with the STRAPS of licensees that deployed earlier. Elefante Group believes that the Commission should rarely have to become involved during STRAPS-STRAPS coordination. The same SBCS licensees, Elefante Group expects, would, over time, encounter each other for coordination on multiple occasions and develop a set of tools that they use with each other to maximize use of the spectrum in and service to overlapping areas.

c. Coordination of UT Links

Elefante Group proposes that, simultaneously or following the STRAPS coordination described above, the SBCS licensee engage in pre-coordination of UT links in the 21.5-23.6 GHz ("23 GHz") band within the coverage area based on the intended coverage area beneath the contemplated nominally-fixed position of the STRAPS. During this process, the licensee will not coordinate specific planned UT links but instead will notify all existing non-Federal FS licensees, and applicants with coordinated links, within the coverage area and provide an interference analysis in order to establish contours that must be protected on the frequencies within the 23 GHz band being used by the respective FS licensees, subject to methods that will permit compatibility around each license.

With respect to Federal fixed operations, the SBCS licensee should be required to notify NTIA of the planned coverage area and frequencies and receive prior coordination guidance from the Federal government.[122] Elefante Group envisions that the response from NTIA will inform the SBCS licensee where UT links can be deployed within the coverage area without further coordination (and on which frequency ranges), while letting licensees know where further coordination with the Federal Government will be required by the SBCS licensee before UT links can be deployed. Subsequent to such coordination, the SBCS licensee can deploy and register UT links[123] consistent with the results of the prior coordination without further process.[124]

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[122] Elefante Group has initiated discussions with affected federal agencies to further develop these proposals.

[123] The registration of the UT links will facilitate coordination and deployment of other FS links on traditional ground-based systems compatibly with the UT links.

[124] As new traditional FS links are coordinated and deployed after the UT links are pre-coordinated, the SBCS licensee would provide notification to the owner of the new FS links and update the pre-coordination.

Once links are registered, like STRAPS registrations, they should be subject to the putting into use and discontinuance requirements generally applicable to the wireless services.[125] In other words, if they are not actually deployed within the requisite period for site-based licenses, they should be removed from the register so as to not restrictively impact coordination's of SBCS, FS, or other users unnecessarily and indefinitely. Similarly, the generally applicable discontinuance rules should apply to registered links as well, for similar reasons.

The pre-coordination and registration framework proposed by Elefante Group will permit rapid deployment of UT links allowing SBCS licensees to be highly responsive to customer requests with minimal delays while ensuring sufficient protection of incumbent users and the ability of traditional FS services to expand in the same manner they can today.

d. Professional Installation of UTs

The SBCS rules should make clear that any UTs (and gateway ground radio equipment) must be professionally installed to ensure links are consistent with the pre-coordination procedures described above.

F. Technical and Operational Parameters for STRAPS-UT Operations

Because, as Elefante Group proposes, SBCS systems operating in the 22-23 GHz and 26 GHz bands should do so compatibly with other incumbent uses, as well as other SBCS operators, technical and operational limits for SBCS are appropriate. With respect to some sharing scenarios, the technical limits proposed may result in sufficient margin with incumbent uses to permit sharing, taking advantage of geometric diversity and other factors inherent in SBCS deployments. For example, an EIRP density limit on UTs prevents harmful interference into

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[125] *See Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95 and 101 to Establish Uniform License Renewal, Discontinuance of Operating and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services*, WT Docket No. 10-112, Second Report and Order and Further Notice of Proposed Rulemaking, FCC 17-105 (2017).

Iridium ISS cross-links.[126] Where possible, compatibility should be explicitly incorporated into the rules, minimizing wherever possible the need for coordination or other additional procedures. In other cases, compliance with the technical limits must be combined with coordination procedures and, depending on the circumstances, mitigation undertaken by the SBCS operator or later users of the bands. The technical and operational parameters that the Commission should consider implementing in the rules to help ensure compatible access to the spectrum are described below.[127]

1. General Proposed Technical Parameters

To promote innovation and competition in an emerging new service, such as SBCS, Elefante Group contends that technical limits should be described in their most generalized form in the parameters specifically relevant for interference (i.e., EIRP density or incident PFD) rather than overly prescriptive parameters that might dictate implementation and limit the technological approach. For example, a limit on EIRP within the band of a potential out-of-band victim is superior to a regulation specifying specific guard band sizes, roll-offs, waveforms, or filter parameters, all of which are tradeable within different system designs to achieve the real protection goal while maximizing the SBCS system's performance objectives. Sections 101.111 and 101.115 should be amended accordingly.

a. PFD Limits on User Downlinks

To provide adequate protection to terrestrial receivers, satellite services operating in bands where they are co-primary with terrestrial services must limit their power flux density on

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126 For a further discussion, please *see* Appendix C.

127 Several of those parameters are discussed above, such as the STRAPS altitude range, the need to operate STRAPS at a nominally fixed position, and the minimum elevation angle of STRAPS-UT links.

the ground as a function of the incident elevation angle. This establishes a predictable interface for both services to plan around. Elefante Group proposes that STRAPS downlinks, given the similar overhead geometry of STRAPS to satellites, be subject to the same power flux density limits. Section 25.208 (c) of the Commission's rules, 47 C.F.R. § 25.208(c), describes limits for the 24.45-24.75 GHz band (close to the SBCS downlink band of 25.25-27.5 GHz) as:

> (1) −115 dB (W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane.
>
> (2) −115 + 0.5 (δ-5) dB (W/m^2) in any 1 MHz band for angles of arrival d (in degrees) between 5 and 25 degrees above the horizontal plane.
>
> (3) −105 dB (W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Elefante Group notes that these limits are the same as the international PFD limits in Article 21 (Table 21-4) of the Radio Regulations that apply to both the 24.45-24.75 GHz and 25.25-27.5 GHz bands.

b. EIRP Density Limits on User Uplinks

Elefante Group proposes a maximum EIRP density for any UTs in clear sky to protect space station receivers. Specifically, Elefante Group proposes that EIRP density be limited to 20 dB(W/MHz), consistent with compatibility studies Lockheed Martin conducted to protect space stations, e.g., Iridium and NASA TDRSS space stations.

EIRP density limits can also help maintain compatibility – *i.e.*, make successful coordination at a desired UT location more likely – with other Fixed Service stations. EIRP density from SBCS UTs in directions below 10 degrees elevation angle (directions that will be in sidelobes of SBCS UTs necessarily pointed at high elevation angles) will remain consistent with the absolute emission limitations described in 101.111. To be consistent with the results of Lockheed Martin compatibility studies appended hereto without limiting system design by

separately prescribing antenna patterns, channel width, and power, an overall maximum EIRP density as a function of antenna off-boresight angle is proposed to bound a family of patterns assessed in compatibility analyses.[128] From Lockheed Martin compatibility analyses it has been determined that the highest EIRP density patterns of SBCS UTs will require more aggressive sidelobe suppression in order to improve compatibility than what has typically been regulated.

As noted earlier, atmospheric attenuation, while better in the proposed bands than higher frequencies, will be an issue, especially for STRAPS seeking to communicate with UTs at the edge of a coverage area. To overcome weather losses in non-clear sky conditions, SBCS UTs should be permitted to utilize Automatic Transmit Power Control ("ATPC") to increase EIRP density circumstantially to the extent necessary to maintain the same Received Isotropic Power (RIP) at the STRAPS. In this situation, space stations on the same UT boresight vector, for example, will similarly see no increase in interference. To maintain compatibility with space stations receiving emissions from an angle off the UT boresight, which may not pass through the same weather cell and therefore experience lower weather losses, limits on this exceedance may be appropriate.[129] To maintain compatibility with terrestrial stations along paths without weather loss, the emission limits below 10 degrees elevation remain unchanged.

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[128] An example EIRP density mask for UT uplink is shown in Appendix T (SBCS uplink to SBCS uplink compatibility study).

[129] The size of weather cells determines the extent to which a UT performing ATPC based on the boresight link through weather to a STRAPS could exceed intended limits in directions off boresight. If weather losses off boresight decrease more slowly than gain decreases off boresight (or even increase), RIP at targets off boresight will be lower than in the clear sky condition where no ATPC has been applied to increase power. If weather losses off boresight decrease more rapidly than the gain off boresight decreases, more RIP at targets off boresight will be higher than in the clear sky condition. Elefante Group and Lockheed Martin continue to study this scenario.

c. Receive Gain Roll-Off Requirement for User Downlinks

Compatibility analysis conducted in Appendix U (SBCS downlink to SBCS downlink compatibility study) shows that adequate sharing between SBCS systems requires that UTs use directional receive antennas aimed toward their STRAPS to provide spatial isolation from potentially interfering downlink transmissions from a neighboring STRAPS. To permit STRAPS to operate in proximity so their service areas can overlap over the same market will require a UT receiver antenna patterns operate with a minimum gain roll-off specified as a function of off-boresight angle.

An example gain roll-off requirement for UT receive antennas is shown in the compatibility study. Although receive gain typically has not been specified in regulation (except as implied by transmit gain), Elefante Group urges adoption of this criterion as necessary for compatibility between SBCS systems. The requirement would establish a minimum technical threshold a system must take in order to expect protection, keeping inefficient systems from preventing overlapping coverage from other systems.

d. Emission Limits Protecting Specific Station Categories

Based on the compatibility studies it has performed to date, Elefante Group submits that, in specific limited circumstances, existing stations in certain co-primary services in some sub-bands that this Petition proposes require additional protection beyond the general limits Elefante Group proposes above for either SBCS uplinks or downlinks.

i. <u>Maximum PFD Incident on SRS/EESS Earth Stations</u>

Based on the Lockheed Martin analysis, Elefante Group proposes that a limit on the PFD projected from STRAPS on federal SRS and EESS Earth Stations in the 25.5-27 GHz band lower than the proposed general limit on PFD is necessary to prevent harmful interference when the

Space Station the Federal User is tracking passes behind a STRAPS. This limit[130] is only actually necessary when the stations point within a small angle of the STRAPS toward federal SRS and EESS Earth Stations. Elefante Group expects that SBCS implementations will require a resource manager capable of tracking such geometry. Consequently, STRAPS should be required to coordinate with federal SRS and EESS Earth Station operators to limit the PFD level below the general limit only to address those situations where an in-line interference event would merit it.

ii. <u>Maximum PFD Incident on RAS Sensors from STRAPS</u>

RAS observations in the 23.6-24 GHz band will receive out of band emissions (separated by 1.25 GHz) from the 25.25-27.5 GHz SBCS downlink. Elefante Group proposes that PFD averaged over the 23.6-24 GHz band be limited to -193 dB(W/MHz/m^2) (corresponding to a maximum 0.1% data loss per STRAPS observed from the RAS site and higher than a 5 degree elevation angle). Based on Lockheed Martin's compatibility analyses, this will provide sufficient protection from harmful interference to meet the applicable interference protection criterion.

iii. <u>Maximum EIRP Directed at Adjacent Band EESS Sensors</u>

Prevention of harmful interference from an SBCS uplink into the 21.2-21.4 and 23.6-24 GHz EESS passive bands requires that the interference received by any one sensor in those bands (as described in Recommendation ITU-R RS.1861) not exceed their permitted I/N criteria more than some percent time (as described in Recommendation ITU-R RS.2017). Because

[130] The limit is specific to equipment at each station. Examples are quantified in document # USWP5C19_58_04 section 2.3.3.1 in the ITU working party 5C analyses for HAPS and has been quantified in ITU HAPS studies. One example derives a PFD limit formula for protection of a 34m SRS antenna which includes a minimum limit of -183.9 dB(W/m^2/MHz) at boresight to -121.3 dB(W/ /MHz) at 5 deg off boresight.

different SBCS implementations (with different numbers of UTs and different UT EIRP densities, beam patterns, and channel bandwidths) will present statistically different interferences, the proposed protection is given in a form equal to maximum EIRP density, much as the general limit. The proposed limit includes 1) a conservative, bounding regulatory limit determined by protection 100% of the time, 2) a process to demonstrate compliance of a specific SBCS implementation with the percent time protection criteria.

Consistent with the Lockheed Martin bounding compatibility studies appended to this Petition and determining limits to prevent harmful interference 100% of the time, in the absence of a statistical analysis showing that a lower EIRP is justified, the maximum aggregate EIRP from a STRAPS and its associated UTs toward an EESS sensor should be limited to:

- In the 23.6-23.4 GHz band: [-32.5] dBW over a 200 MHz reference band
- In the 21.2-21.4 GHz band: [-35] dBW over a 100 MHz reference band

e. Efficiency of Spectrum Use

The Commission, as part of seeking comment on the Petition, should invite comment on what an appropriate criterion should be. Elefante Group submits that an appropriate criterion should be in terms of the bps/MHz/km^2 that an SBCS, as deployed, can deliver.[131] This metric would take into account three key terms for efficiency: maximum capacity (data rate) the system can provide (bps) in the authorized spectrum (Hz) and service area registered (km^2). This metric reflects the value the SBCS brings in terms of service *versus* the value of the two key resources granted an SBCS, spectrum and the STRAPS service area over which it is granted co-primary protection as it deploys STRAPS-UT links. It combines the metrics of spectral efficiency and

[131] Precedents for minimum spectral efficiency criteria include a minimum of 0.125 bps/Hz for transmitters in 71-76 and 81-86 GHz, and 1 bps/Hz for transmitters in 92-94 GHz per 47 C.F.R. § 101.147(z)(2).

capacity density (the data that can be delivered per unit area served). As an illustration, the Elefante Group reference system design will yield 32,555 bps/MHz/km^2 because of its spectrum reuse and other system characteristics.

Systems that deliver more data with the same or more limited resources should be encouraged. Systems that use the spectrum less efficiently and materially preclude highly efficient SBCS from being able to reach locations should be discouraged.

2. Refraining from Other Technical or Operational Limits

As Elefante Group has explained throughout this Petition, it asks the Commission to establish a regulatory framework by which SBCS can gain access to the 22-23 and 26 GHz bands while operating compatibly with existing co-primary users. This will maximize spectrum utilization in the bands without harming or inhibiting value derived by existing users, as well as preserve opportunities for the growth of both SBCS and existing uses. To ensure protection of incumbents from harmful interference without unnecessarily prescribing SBCS implementations, and therefore limiting the value that can be derived from multiple competing approaches, Elefante Group refrains from proposing certain regulations, providing several key examples below.

a. Channel Allocation / Band Plan

Different service objectives will drive different uses of the available spectrum by SBCS. As an example, one system might divide the allocation into sub-bands and employ a beam laydown pattern with color reuse. Another system might use the entire band in one channel across multiple beams at different times, requiring larger guard bands to adjacent services to ensure sufficient roll-off for their protection. As long as the regulatory limits ensuring adequate protection to other systems and services are achieved by the implementation, their purpose is served and the different SBCS implementations should be permitted.

Thus, the Commission should not insist on any channelization by SBCS operators. Studies conducted by Lockheed Martin on compatibility between SBCS in the downlinks direction and between SBCS in the uplink direction show more than adequate sharing between SBCS is possible even under the worst case assumption of complete overlap of interferer bands with victim bands.[132] Thus no stipulation on channelization is necessary, and channel decisions should be left to the discretion of each SBCS operator. For these reasons, as explained elsewhere, when an SBCS operator obtains a license, it should be permitted to have access to the entire band, on a non-exclusive basis, with its rights triggered when a STRAPS is registered and deployed in a timely fashion.

b. STRAPS and UT Transmitter Characteristics

With the general PFD proposed above (as a function of elevation angle),[133] Elefante Group submits that there is no need to separately specify limits on antenna input power or antenna gain patterns. A system design in which the maximum possible PFD from the STRAPS and EIRP density and gain pattern roll-off from the UTs is controlled within the general limits is sufficient.

Similarly, the band specific PFD and/or EIRP density limits proposed earlier will ensure compatibility with other services out of band and provide an absolute mask on the most relevant parameters. Consequently, there is no need to separately specify out of band emission masks on antenna input power or gain patterns. A system that demonstrates compliance with the band-specific PFD and EIRP density limits is sufficient.

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[132] *See* assumptions used and sharing results in Appendix U (SBCS uplink to SBCS uplink compatibility study) and Appendix T (SBCS downlink to SBCS downlink compatibility study).

[133] *See supra* Section IX.F.1.a..

G. Licensing and Coordination in the E-Band

SBCS licensees should be able to obtain nationwide licenses as do Fixed Service operators in the 70/80 GHz bands today, which allocation should be added to Section 101.147 of the Commission's rules. Individual feeder link paths, both to and from the STRAPS, should be coordinated and registered much as are Fixed Service links in the E-Band today, including coordinating with Federal links as described in the Part 101 rules.

Other proposed E-Band rules changes are discussed below:

1. Proposed Operational Parameters and Rules for Gateways

In the Elefante Group reference design, multiple feeder links are established between terminals at terrestrial gateway sites and terminals on the STRAPS. The gateways are located close enough to the STRAPS nominal latitude and longitude that, as the STRAPS performs station keeping within the registered control volume around its nominal station, they point to track the STRAPS position from between a maximum of 90 degrees elevation angle and a minimum of 45 degrees elevation angle. This presents a large area (~10 km circular radius) to locate gateway locations that are suitable and can be coordinated.

Other SBCS designs may use other parameters permitted through Part 101 rules and may not seek to adhere to the parameters above. It can be anticipated, however, that lower elevation angles will present more challenges in coordination as well as greater free space and weather losses reducing spectral efficiency.

2. Current Rules Largely Support SBCS Feeder Links

Feeder links are proposed to largely conform with existing rules within Part 101 for fixed microwave links. Because they will use the same technical characteristics in Subpart C of those

rules[134] and comply with the same service and technical rules described in Subpart Q,[135] there is almost no need to distinguish rules for SBCS feeder links.

3. Technical Rule Changes to Support SBCS Feeder Links

Elefante Group believes that feeder links in the E-band can by and large be governed by the current rules in Part 101 that govern fixed link in the bands with minimal changes. To ensure that compatibility with several other services is achieved through regulatory compliance rather than requiring coordination, some additional rules may need to apply to links in the E-Band. Specifically, an elevation angle threshold that specifies lower EIRP density limits may be appropriate for consideration.[136]

In addition, the current regulation limiting amplifier power to 3W set in Section 101.113(a), footnote 13 of the Commission's rules should not apply to SBCS links in the E-Band. The key criterion for compatibility with other services and coordination with other fixed microwave links is not amplifier power but max EIRP density as a function of off-boresight angle. A design incorporating higher-power amplifiers could meet this necessary compatibility criterion while being entirely compliant with the other regulations applicable to E-band fixed links limiting maximum bandwidth, maximum EIRP, maximum 3 dB beamwidth, and minimum boresight gain.[137]

H. Cross-Border Issues

Elefante Group believes that SBCS ground stations in the 21.5-24 GHz range as proposed herein would not result in harmful interference to radio stations in Mexico or Canada operating

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134 47 C.F.R. § 101.101-151.

135 47 C.F.R. § 101.1501-1527.

136 Currently there is no limit in the FCC's rules on elevation angle of fixed microwave links in the E-band.

137 47 C.F.R. §§ 101.1505, 101.113, 101.115

in conformance with the ITU table of Frequency Allocations. Stations near the borders would need to coordinate as set forth in Part 1 of the Commission's rules.[138] As it moves forward with a notice of proposed rulemaking for the SBCS, the Commission should initiate a coordination process with these neighboring countries to ensure that conflicting operations do not result. Fortunately, the nature of SBCS, such as the beam control Elefante Group plans to institute, should allow a high degree of coordination. Both Canada and Mexico may identify numerous beneficial uses of SBCS in the bands selected[139] and recognize the high potential for compatible operation with other co-channel uses already employed or planned in those countries.

X. SBCS USES TRANSFORMATIVE NOVEL TECHNOLOGIES AND CONSTITUTE NEW SERVICES QUALIFYING THE PETITION FOR TREATMENT UNDER SECTION 7 OF THE COMMUNICATIONS ACT

Last year, Chairman Pai signaled his commitment to "breathe life into Section 7 of the Communications Act—or maybe the more proper metaphor would be to add teeth…Going forward, if a petition or application is filed with the FCC proposing a new technology or service, we'll supply an answer within a year." [140] This Petition requests a rulemaking that would allow unprecedented and transformative stratospheric communications delivery technologies – which will yield considerable public benefits – to obtain access to adequate spectrum that will allow key next generation services to be offered. As such, the Petition should be treated by the Commission as subject to Section 7 of the Communications Act of 1934, as amended.[141]

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138 47 C.F.R. §1.928.

139 Some adjustment to the language in 101.1527 specifying coordination with Canada and Mexico may be necessary to accommodate the overhead geometry of STRAPS-UT links.

140 Remarks of FCC Chairman Ajit Pai at Carnegie Mellon University's Software Engineering Institute, "Bringing the Benefits of the Digital Age to All Americans" (Mar. 15, 2017), available at https://www.fcc.gov/document/chairman-pai-bringing-benefits-digital-age-all-americans.

141 *See* 47 U.S.C. § 157.

Section 7(b) requires "[t]he Commission [to] determine whether any new technology or service proposed in a petition or application is in the public interest within one year after such petition or application is filed."[142] For the reasons given below, the Commission should adopt the requested Notice of Proposed Rulemaking ("NPRM") within one year. Similarly, once the rulemaking is commenced, the Commission should adopt rules – necessary spectrum allocations as well as technical, operational, and licensing rules – for SBCS within another twelve months. This will allow Elefante Group and any other interested party ready to do so, to obtain and deploy additional resources to rapidly deploy STRAPS to provide SBCS in time frames consistent with when many ground-based carriers are looking to roll out their 5G, next generation networks.[143]

The Commission has not yet adopted rules to implement Section 7, but it has proposed a framework under which it should evaluate requests for Section 7 treatment. Indeed, earlier this year, the Commission adopted a pending NPRM to establish guidelines and procedures to govern Section 7 requests.[144] But the Commission need not complete that rulemaking before acting on

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142 47 U.S.C. § 157(b).

143 *See* Brian Heater, TechCrunch, *The Promise of 5G is Still Years Away*, (Mar. 1, 2017), available at https://techcrunch.com/2017/03/01/5g-at-mwc/ (explaining that while 5G handsets will start arriving in 2019, "the most optimistic projections set 2020 as a date for wider rollout", and that 5G rollouts will occur between 2020 and 2025); Dan Jones, Light Reading, *Verizon Says its Fixed 5G Will Arrive in 2018, Mobile in 2020*, (Mar. 7, 2017); Elizabeth Zima, Government Technology, *What is 5G, and Why Will It Take So Long To Arrive?*, (April 12, 2018), available at http://www.govtech.com/network/What-is-5G-and-Why-Will-it-Take-So-Long-to-Arrive.html (explaining that "5G deployment is not imminent", and that while "companies like Verizon and AT&T are trying to stir up their stockholders" by announcing the deployment, "most cities will not see the deployment of the technology in 2019.").

144 *See Encouraging the Provision of New Technologies and Services to the Public*, GN Docket No. 18-22, Notice of Proposed Rulemaking, FCC 18-18 (rel. Feb. 23, 2018) ("Section 7 NPRM").

Elefante Group's requests for Section 7 – the Commission's statutory obligation to act within one year has long been fully in effect.[145]

Elefante Group's new persistent stratospheric communications technologies and services are in the public interest and meet all of the proposed requirements of the statute and the proposed provisions of the NPRM (were they in effect). First, SBCS has not been previously authorized by the Commission. Second, stratospheric communications systems differ substantially and in important ways are an improvement on currently authorized technologies and services. Third, Elefante Group's systems, which have been under development in close collaboration with Lockheed Martin for more than two years, are technically feasible and commercially viable. Finally, Elefante Group and other SBCS systems, if given access to adequate spectrum resources and are permitted to deploy, would serve the public interest by, among other things, allowing unprecedented rapid deployment of market-wide wireless broadband infrastructure overcoming many obstacles that other traditional deployments regularly face, helping to close the Digital Divide, enabling and complementing deployment of

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[145] As the Commission recognizes in the Section 7 NPRM, the Commission "has considered [Section 7's] provisions in a handful of cases." Section 7 NPRM, ¶ 4. Footnote 4 of the Section 7 NPRM lists those cases. In many cases the Commission determined that the petition or application did not seek authorization for a "new technology or service." *See* Section 7 NPRM, n. 4 citing to *Southwestern Bell Telephone Co. Revisions to Tariff FCC No. 6,* Memorandum Opinion and Order, 6 FCC Rcd 3760, 3764 (1991) (the reference to "new technology or service" in Section 7(b) "cannot be interpreted to endorse methods for the provision of existing services at additional locations or the continued use of older, outmoded technologies"); *TelQuest Ventures, LLC,* Memorandum Opinion and Order, 16 FCC Rcd 15026, 15037 (2001) (a proposal to offer "an additional DBS service option" did not qualify as a "new service" under Section 7); *Applications for License and Authority to Operate in the 2155-2175 MHz Band*, Order, 22 FCC Rcd 16563 (2007) (dismissing the application of M2Z to provide a national broadband radio service, finding that the proposal did not fall within Section 7 because the proposed broadband service and technologies to be used were already in use by other carriers in other frequency bands, often at faster speeds than proposed by M2Z), *affirmed, M2Z Networks, Inc. v. FCC,* 558 F.3d 554 (D.C. Cir. 2009) (M2Z v. FCC). As will be demonstrated herein, Elefante Group's persistent stratospheric communications technologies and services are "new technologies and services" as the Commission has proposed to define that term in the Section 7 NPRM.

4G, 5G and IoT-enabling services and technologies in urban as well as rural environments, maximizing spectrum utilization through spectrum sharing with incumbent services, and making communications networks more resilient and responsive during and following natural and man-made disasters.

A. Elefante Group's Proposed New Technology and Service Has Not Been Previously Authorized by the Commission and Differs from Existing Technologies and Services, and Offers a Novel Approach to Spectrum Sharing

Chairman Pai in his speeches and in the NPRM has been clear that in order to receive Section 7 processing within one year, a proposed technology or service must be truly new, which can include technologies and services that have not been previously authorized by the Commission and differ from technologies and services that have already been authorized.[146] Elefante Group's proposed SBCS technology and services are new on at least three independent bases.

First, no other persistent stratospheric communications technology or service has ever been authorized by the Commission (or any other administration as far as Elefante Group is aware). Although many existing technologies and services allow access high-speed broadband connectivity for residential and enterprise customers, wireless carrier backhaul, and IoT-enabling sensing and communications capabilities, none of the previously authorized technologies and services employ persistent stratospheric infrastructure. This is not surprising because, as described in Section II above, a series of technological breakthroughs and developments, many by Lockheed Martin, have come together to allow Elefante Group to plan to deploy the commercial SBCS systems it contemplates – effectively the first in the world – in the next few

146 *See* Section 7 NPRM at ¶ 16.

years. Nor do existing communications platforms employ the types of antennas and other technologies, delivery method, and capabilities that Lockheed Martin is developing and Elefante Group will employ.[147]

Second, as discussed in detail in Section VII., the novel design of Elefante Group's SBCS system will permit a high level of spectrum efficiency and compatibility with other terrestrial systems, including other stratospheric deployments serving the same geographic areas, as well as ISS and Federal users of the radio frequency spectrum. This combination of spectrum compatibility and efficiency in encumbered spectrum is unprecedented to Elefante Group's knowledge and should be a model for spectrum access the Commission encourages in this era where demands on spectrum continue to increase. Crucially, this novel spectrum sharing design will serve the public interest by allowing incumbent service to continue to grow while Elefante Group's SBCS meets its operational requirements.

Third, as described in Section IV, SBCS allow significant instantaneous network capacity to be provided market wide in a way that no other system can offer. As Elefante Group explained above, this yields numerous benefits which, if encouraged by the Commission providing SBCS access to adequate spectrum and adopting rules in a timely manner, could give the United States an edge in the "race to 5G."

B. Elefante Group's Proposed Persistent Stratospheric-Based Communications Technology and Service Is Technically Feasible

While Elefante Group's proposed SBCS is certainly a new technology and service, by drawing on Lockheed Martin's, decades of experience with LTA system development and

[147] Both the communication payload and the airship represent a blend of elements relying on new innovations that includes established Elefante Group and Lockheed Martin intellectual property not limited to beam switching, waveform helium retention, unmanned operations as well as commercial evolving technologies (e.g., battery cell).

communications technologies and further breakthroughs in the relevant technologies pursuant to the collaboration between Elefante Group and Lockheed Martin over the past thirty months, Elefante Group's SBCS is technically feasible. As detailed in Section II., Lockheed Martin has an unparalleled airship legacy that traces its LTA origins to more than a century with the development of manned and unmanned balloons for the military. In the last 15 years, Lockheed Martin led the development of two stratospheric airship programs (HAA and ISIS) for U.S. government agencies. Both programs developed technologies essential for successful deployment of SBCS, including fabric development, hull designs, power systems, propulsion, vehicle management, communications, and ground systems. In addition, power cell technologies from the Lockheed Martin Space have been developed based on decades-long experience in the design of highly reliable power subsystems for space systems.

Further, SBCS, as envisioned by Elefante Group, will require successful compatible operations. In Section VII.C. and in the Appendices, Elefante Group describes in detail how its SBCS system will be able to operate compatibly with incumbent uses while they continue to grow. Conversely, Elefante Group's SBCS systems will be able to meet high level performance requirements in the presence of such other incumbent services.

C. Elefante Group's Proposed Persistent Stratospheric-Based Communications Technology and Service is Commercially Viable

SBCS as contemplated by Elefante Group, to serve not only urban areas, but rural areas as well, is commercially viable. Elefante Group expects the demand for low-latency, high capacity connectivity services to continue to grow exponentially into the foreseeable future. Elefante Group's proposed SBCS will provide a stratospheric network layer that sits between terrestrial and space communications networks, combining the best elements of performance with compelling coverage and capacity economics. Elefante Group has extensively modeled its

own business case and expects to offer wholesale services more efficiently and at a substantially lower total cost than new network deployments and at highly competitive rates and performance when compared to currently deployed traditional network infrastructure and services.[148] As such, Elefante Group's services will help lead the effort to win the race to 5G.

Elefante Group's proposed SBCS will bring new competition to the market for multiple services including high-speed broadband connectivity to residences and businesses, ultra-high capacity broadband connectivity to establish secure private lines and networks for enterprises, wireless carrier backhaul for connecting small cells to network infrastructure to meet network densification needs of 5G, and IoT-enabling applications combining sensing and communications capabilities. Importantly, as opposed to many business-cases for terrestrial network deployments, Elefante Group's SBCS solution provides uniform, market-wide coverage that does not differentiate between high return and low return neighborhoods, helping to lower the Digital Divide. Conversely, Elefante Group's deployments will not encounter the same sorts of infrastructure obstacles, delays, costs, and points of failure that more traditional ground based deployments will. Furthermore, in many cases Elefante Group expects the future coverage of its SBCS to extend beyond the boundaries of urban centers to cover surrounding suburban and rural areas that are currently under-served. All of these factors make the services Elefante Group will provide using its SBCS system extremely viable and valuable.

Underpinning the commercial viability of Elefante Group's SBCS is the ability to provide a vastly superior cost per bit per square kilometer versus traditional terrestrial infrastructure, while maintaining equivalent performance in terms of latency and capacity, which space-based

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[148] *See supra* note 20 and accompanying text regarding Elefante Group's expectation to be able to deliver a substantially lower cost per bit per square kilometer than either terrestrial or satellite services while maintaining performance comparable to terrestrial systems in terms of capacity and latency.

infrastructure cannot support. This is possible because of unique switching technology which will provide a "Network in the Sky" as well as the ability to keep station at such a close proximity to user terminals to provide very low latency that next generation network applications will demand. Critically, the ability to keep station allows for an efficient re-use of spectrum and hence high capacity payloads that lower the cost per bit delivered.

Elefante Group has demonstrated in this Petition, including in Sections III that, working with Lockheed Martin on the technologies, the Company has unparalleled practical real-world experience with designing, building and testing LTA airships, developing and integrating new technologies, and deploying and operating large scale network infrastructure. That experience has caused Elefante Group and Lockheed Martin to make substantial investments of capital and time to further develop LTA airships and relevant communications technologies. Based on Lockheed Martin's experience with LTA technology and infrastructure, recent technological improvements, the substantial investments received and continuing in the project, and detailed business plan analyses, the proposed SBCS is commercially viable.

D. Elefante Group's Proposed Persistent Stratospheric-Based Communications Technology and Service Would Serve the Public Interest

As demonstrated in detail in Section IV, Elefante Group's proposed SBCS and infrastructure will help to advance key Commission policy objectives and serve the public interest in ways that existing communications technologies and services cannot. Based on years of innovation and millions of dollars of private investment (which are both ongoing), Elefante Group's proposed new SBCS will help lead the Unites States to win the 5G race. Elefante Group's SBCS systems will provide new competitive choices for high-speed broadband connectivity to residences and businesses as well as enterprises, business, and carriers, ultra-high capacity broadband connectivity to establish secure private lines and networks for enterprises,

wireless carrier backhaul for making metro area networks more robust and connecting small cells to network infrastructure to meet network densification needs of 5G, and IoT-enabling applications combining sensing and communications capabilities for control, location, aggregation, processing and packaging of data across large and/or remote geographic areas to meet the projected growth in IoT devices and increased data usage.[149]

SBCS will promote numerous Commission and Administration objectives, as detailed earlier: (1) private investment in high speed broadband infrastructure; (2) closing the Digital Divide by improving the above-referenced services in unserved and underserved areas; (3) densification and deployment of 4G, 5G, and IoT-enabling technologies; (4) maximization of spectrum efficiency and band utilization; (5) forward-looking spectrum sharing; (6) rapid deployment and restoration of communications capabilities enhancing public safety and disaster relief; and (7) the creation of tens of thousands of American jobs in areas such as engineering, construction, and operations.

In Section V, this Petition described in detail how Elefante Group's stratospheric platforms and planned communications payloads will allow it to bring relative advantages to wholesale customers that other communications delivery methods do not offer. Elefante Group's SBCS can offer spectrally efficient payloads with frequency reuse higher than other communications systems, but with the latency and greater link data rates comparable to ground-based systems. The beam sizes, number of beams and ability to customize the footprint relative to satellites allows Elefante Group's stratospheric solutions to target unserved and underserved areas with micro precision. Elefante Group's stratospheric platforms will have larger potential service areas than ground system base stations with minimal infrastructure requirements and with

[149] *See supra* Section IV.A.-B.

more efficient opportunities for maintenance, repair and replacement as part of regular, periodic platform switchover in a matter of months, rather than the years it would take to replace a ground-based network or a constellation of satellites. Finally, in contrast with ground-based communications systems and with possible advantages over satellite systems, stratospheric platform communications will support rapid deployment and restoration of communications capabilities at high capacities after natural and man-made disasters, enhancing public safety and disaster relief efforts.

* * *

In sum, Elefante Group's proposed persistent stratospheric communications infrastructure is a new service based on new technology, which should be considered by the Commission pursuant to Section 7. Based on the demonstration provided herein, the Commission should adopt an NPRM to seek comment on this Petition within one year and adopt an order with a spectrum allocation and licensing and service rules for persistent stratospheric communications services within another twelve months so that SBCS license applications can be filed and considered and SBCS systems can be deployed as soon as they are ready. This will allow the U.S. to lead not only in 5G deployment, but also in the technological innovation of commercial stratospheric platforms and services.

XI. CONCLUSION

For the reasons set forth herein, the Commission should swiftly – and in any event within one year – initiate a rulemaking to adopt a regulatory framework to give SBCS systems access on a non-exclusive basis to spectrum in the 21.5-23.6 and 25.25-27.50 GHz ranges for STRAPS-UT links and access to 71-76 and 81-86 GHz for feeder links, promulgate appropriate technical and operational rules to promote compatibility with existing users in the bands, and non-exclusive licensing rules. The Commission should also complete that rulemaking swiftly within one year, if not sooner, to allow Elefante Group and other interested providers, to deploy SBCS systems in a timely fashion so as to accelerate the deployment of next-generation technologies and services to benefit urban and rural areas.

Respectfully submitted,

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