Exhibit A
HawkEye 360, Inc.
Response to Question 43, FCC Form 312

I. Description of Application

HawkEye 360, Inc. ("HE360") is a Delaware corporation with its headquarters and operations located in Herndon, Virginia. With this application HE360 requests authority to launch, operate and replenish a constellation of up to sixty (60) to eighty (80) operational low-Earth orbit, non-geostationary ("NGSO") microsatellites ("HE360 Constellation").[1] The total number of satellites to be launched and operated over the 15-year term of the requested satellite license is one hundred and sixty-five (165) to two hundred and twenty (220). The HE360 Constellation will be used to receive and sense radio frequency ("RF") spectrum and survey and map usage of certain radio frequencies within the electromagnetic spectrum. The data collected will also be used for triangulating the location of RF emitters and providing various value-added analytic products and services, including emergency support services, maritime domain awareness products, and interference and piracy detection services, all as more specifically described in Section II below.

The satellites comprising the HE360 Constellation will primarily be launched in clusters of three satellites each ("Hawk Cluster"). A cluster of four satellites may occasionally be used, but the total size of the HE360 Constellation at any given point in time will not exceed eighty (80) operational microsatellites. The total size of the HE360 Constellation will be dependent on market demand for certain products and services, and the collection capacity required to meet customer requirements. The design life of the satellites is three (3) years. HE360 plans to

[1] Included in the HE360 Constellation is the three satellite "Pathfinder" cluster currently licensed under an experimental license. *See* ELS File No. 0024-EX-CN-2017 (granted Feb. 12, 2018). The total number of satellites in an operational HE360 Constellation will vary depending on the total number of three-satellite clusters and four-satellite clusters that HE360 deploys.

replenish the Hawk Clusters as they reach end of life to maintain the overall scale of the HE360 Constellation.

The first cluster of the HE360 Constellation is anticipated to launch in the fourth quarter of 2019.

HE360's Constellation has been preceded by an experimental earth exploration satellite cluster called Pathfinder.[2] Under Pathfinder's experimental permit, HE360 was able to develop the innovative technology which makes the HE360 Constellation possible. HE360 will use Pathfinder operations to prove the technology concept on-orbit, collect operational performance data, and refine the concept of operations including the approach for data collection, processing, and dissemination. In support of this authorization request, HE360 provides the following information.

II. Overall Description of System Facilities, Operations and Services, and Explanation of How Uplink Frequency Bands Connect to Downlink Frequency Bands (47 C.F.R. § 25.114(d))

A. Description of System Facilities

HE360's Constellation and related facilities will be comprised of:

- a space segment consisting of a constellation of up to sixty (60) to eighty (80) microsatellites, flying in clusters of three (or optionally four);
- and a ground segment consisting of:

[2] The Pathfinder cluster approved in ELS File No. 0024-EX-CN-2017 successfully launched on December 3, 2018.

- ○ an Earth station in the United States (Herndon, Virginia) owned and operated by HE360, used for tracking, telemetry, and control ("TT&C") functions for the experimental Pathfinder cluster;
- ○ leased capacity at the KSAT Earth station in Svalbard, Norway (78° 13' 53" N, 15° 24' 25" E) for early commissioning, TT&C and data transmissions; and
- ○ possible future Earth stations inside and/or outside the United States at locations to be determined, for the purposes of increasing opportunities for data transmissions. HE360 will coordinate all non-U.S. ground stations with Federal operators in the relevant band prior to operating any such stations and requests authority for such communications subject to coordination with relevant Federal operators.[3]

B. Operations and Services

1. Operations

As noted above, the HE360 Constellation will consist of up to twenty Hawk Clusters of three, and in some cases four, microsatellites. The satellites are currently manufactured by the University of Toronto Institute for Aerospace Studies Space Flight Laboratory (SFL) located in

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[3] *See, e.g.*, Application of Planet Labs Inc. for Modification of Authority to Launch and Operate an NGSO Satellite System (call sign S2912), IBFS No. SAT-MOD-20170713-00103, at Condition 7 (granted July 19, 2018)("Transmissions of ... data in the 8025-8400 MHz frequency band many only be made to earth stations coordinated with [NASA]. Planet shall provide the FCC the list of coordinated earth stations.").

Toronto, Canada using a Canadian-origin Commercial Off-The Shelf ("COTS") small satellite bus. The satellites are based on the DEFIANT design and will use a COTS software defined radio ("SDR") communications payload manufactured by GOMSpace.[4] The payload includes COTS RF Integrated Circuit (RFIC) technology paired with a multi-core ARM plus Programmable Field Programmable Gate Array System on Chip (SOC). To achieve desired operational functionality, the COTS SDR is programmed with HE360 proprietary software using the open-source GNU Radio toolkit for SDRs.

Once programmed, each satellite will be able to detect the observable environmental characteristics of RF signals ranging between 100 MHz and 18 GHz. Specifically, each satellite is equipped with a suite of antennas including VHF and UHF monopole antennas, S-band and L-band patch antennas, a button antenna for the 1-8 GHz frequency range, and a directional horn antenna for frequencies between 6 GHz and 18 GHz. *See* Table 4 below.

The satellites are only able to detect the observable environmental characteristics (*e.g.*, Time of Arrival ("TOA"), Frequency of Arrival ("FOA"), modulation type, signal bandwidth and signal power) of certain RF signals ranging between 100 MHz and 18 GHz. *See* Table 4 below. The signals of interest that will be primarily monitored and/or observed by the HE360 Constellation are standard commercial transmissions and have waveforms that in standard operations are public standards or otherwise publicly available. From time to time HE360 may monitor and/or observe, at the request of a customer, custom waveforms of signals of interest,

[4] All satellites in the HE360 Constellation will be materially the same with respect to relevant FCC technical parameters, *e.g.*, radio frequency and orbital debris, but there may be differences in manufacturers and in components over time.

subject to such notice or approval requirements as may from time to time be applicable. While each satellite in the cluster senses the full RF signal as transmitted by the source, it does not demodulate the content of any signal, with the exception of receive-only frequencies that are intended for general reception (*e.g.*, AIS, DSC, EPIRB, and ADS-B).[5]

The satellites each have active propulsion systems using Comet-1000 thrusters provided by Deep Space Industries. These are low-power water electrothermal thrusters with 200 seconds of specific impulse (I_{sp}). The thrusters are impulsive, which allows for short maneuvers that minimize power consumption. The distilled water propellant is non-toxic. Much of the design shares heritage with a previously-flown and successful cold gas thruster developed by SFL. The Comet thruster has also been selected by several other smallsat constellations in very high quantities, demonstrating confidence among a diverse set of companies.

Each Hawk Cluster is flown in loose formation to allow contemporaneous collection of signal data from multiple vantage points for trilateration. Each satellite in a Hawk Cluster operates and is commanded individually from the ground.

The satellites operate in a "store and forward" mode, meaning that all collected information is stored on board until the next downlink opportunity. Each satellite in a Hawk Cluster provides a separate data stream which is downlinked from the individual satellite and then transferred via network backhaul to a terrestrially based cloud computing platform (*e.g.*, Amazon Web Services) for processing to create products for sale to customers. The cloud computing platform is separate from the space and ground segments and uses separate HE360

[5] *See* Section II.D below.

proprietary algorithms to triangulate and otherwise process the data provided by the different satellites.

2. Products and Services

As discussed above, the data downlinked from the HE360 Constellation will be transferred via network backhaul to a terrestrially based cloud computing platform for processing to create products for sale to customers.[6]

Products are initially anticipated to be single source analytics products and subscription services to certain types of data feeds. Products are eventually anticipated to include multiple sources of information, including various types of open-source data, commercial satellite imagery and digital terrain elevation data to create fused data products. Applications for HE360 products and services include:

- Emergency Response Support (search and rescue) – through identification and location of Emergency Position-Indicating Radiobeacon ("EPIRB") and other emergency beacon signals.
- Spectrum Mapping – providing timely and accurate updates for spectrum usage, including developing one of the first-ever global spectrum inventory and mapping processes.
- Ionospheric Monitoring – Measure and monitor the total electron content in the ionosphere, which impacts communications and Global Navigation Satellite Systems.

[6] Downlinked data will consist of environmentally observable metadata including TOA, FOA, modulation type, signal bandwidth and signal power.

- Maritime Domain Awareness – Using signal diversity to combine geolocation of a vessel's automatic identification system ("AIS") broadcast with other RF transmissions from a ship to help validate and identify the true location of a ship – supports applications including detection and prevention of illegal fishing and potentially human trafficking.[7]
- Spectrum Interference and Piracy Detection – Geolocate sources of RF interference for telecommunication systems, including geostationary satellite systems.

C. Orbital Information

The HE360 Constellation at scale will consist of up to 60 to 80 microsatellites flying in clusters of primarily three and, in some cases, four satellites. Each cluster will fly in proximate formation providing multiple vantage points over an area of interest. The HE360 Constellation will consist of up to twenty (20) clusters of three to four (3 - 4) satellites at inclinations of 97, 46.5, and 5 degrees, at a nominal altitude of 575 km. The satellites will be three-axis stabilized using an on-board closed-loop control system. The satellites will be separated from one another by up to 250 km. The standard cluster formation will include two satellites in the same orbital plane separated by 250 km in Mean Anomaly. A third satellite will be approximately equidistant between the lead and trail spacecraft, and will be offset from their orbital plane by up to 10 km in RAAN. *See* Table 1 for the nominal orbital elements. If a fourth spacecraft is present in the cluster, the formation will be adjusted to have two RAAN-offset spacecraft, spaced evenly in Mean Anomaly between the lead and trail spacecraft.

[7] HE360 plans to eventually develop a suite of predictive analytics products based on triangulated RF survey data to support a variety of global health and humanitarian initiatives.

Station-keeping maneuvers will maintain the relative formation of the cluster throughout the life of the mission, typically within a 5-km control box. The initial clusters in the HE360 Constellation will be in polar, sun-synchronous orbit (SSO). Subsequent clusters, including replenishment clusters, will extend to mid-latitude and near-equatorial orbits, with exact inclinations depending on launch availability and coverage needs. Information for each orbital parameter is as follows:

Table 1: Orbital Parameters

	Polar, SSO	Mid-Lat	Near Equatorial
Number of Clusters	8	10	2
Number of Satellites in Each Cluster:	3 - 4	3 - 4	3 - 4
Number of Satellites in HE360 Constellation (60 - 80 total)	24 - 32	30 - 40	6 - 8
Total Number of Orbital Planes:	4	5	1
Celestial Reference Body:	Earth	Earth	Earth
Inclination Angle (degrees) for Each Satellite:	97-98	40-50	0-28.5
Orbital Period per Cluster (seconds)	5770 nominal	5770 nominal	5770 nominal
Apogee	500-650 km 575 km nominal	500-650 km 575 km nominal	500-650 km 575 km nominal
Perigee	500-650 km	500-650 km	500-650 km
Eccentricity	Nearly 0	Nearly 0	Nearly 0

The specific orbital parameters will be determined based on launch availability and, in the case of replenishment, system coverage requirements at the time of replenishment. All of the replacement satellites will meet the National Aeronautics and Space Administration ("NASA") orbital debris guidelines.[8]

D. Frequencies and Frequency Band Connections

1. Frequencies

[8] *See* NASA Technical Standard 8719.14 Revision A (with Change 1), *Process for Limiting Orbital Debris* (May 25, 2012); *see also* Attachment 4 (Orbital Debris Assessment Report).

HE360 requests authority to use the frequencies listed in Table 2 below for its communication links.[9]

Table 2: Communication Links

Frequency Band (MHz)	Use	Transmit Center Frequency (MHz)
X-band: 8025-8400	Primary payload downlink	Sat#1 - 8075 MHz Sat#2 - 8165 MHz Sat#3 - 8255 MHz Sat#4 - 8345 MHz
X-Band: 8025-8400	TT&C downlink	Sat#1 - 8291 MHz Sat#2 - 8297 MHz Sat#3 - 8303 MHz Sat#4 - 8309 MHz
S-Band: 2200-2290	Emergency Backup TT&C downlink	Sat#1 - 2236 MHz Sat#2 - 2242 MHz Sat#3 - 2254 MHz Sat#4 - 2260 MHz
S-Band: 2025-2110	Primary payload uplink	Sat#1 - 2068.2 MHz Sat#2 - 2062.7 MHz Sat#3 - 2077.4 MHz Sat#4 - 2072.0 MHz
S-Band: 2025-2110	TT&C uplink	Sat#1 - 2063.965 MHz Sat#2 - 2064.965 MHz Sat#3 - 2065.965 MHz Sat#4 - 2065.465 MHz
S-Band: 2025-2110	High Speed TT&C uplink	Sat#1 - 2063.965 MHz Sat#2 - 2064.965 MHz Sat#3 - 2065.965 MHz Sat#4 - 2065.465 MHz

The satellites shall be capable of ceasing radio emissions, as required.[10] The carrier frequency of each transmitter shall be maintained within 0.002% of the reference frequency.[11] All emissions shall meet the out-of-band emission limits specified in the Commission's rules.[12]

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[9] *See also infra* Section VI.C (requesting waivers of the U.S. Table of Allocations).

2. Frequency Band Connections

The HE360 Constellation spacecraft have two command and control systems. Each satellite is designed to receive commands from associated ground stations and to downlink telemetry data stored on board the satellite as well as mission data stored on board the satellite which has been collected by a SDR. The collected, processed and stored data onboard the satellites will be downlinked in the 8025-8400 MHz band to the appropriate ground station while the satellites are visible from that particular ground station site at a five degree elevation angle or higher. The transmitter has three possible user data rates: 5 Mbps, 25 Mbps and 50 Mbps. The storage capacity for the payload on board each satellite is approximately 32 GB. The block diagram of the communications system is as follows:

[10] *See* 47 C.F.R. § 25.207.
[11] *See* 47 C.F.R. § 25.202(e).
[12] *See* 47 C.F.R. § 25.202(f).

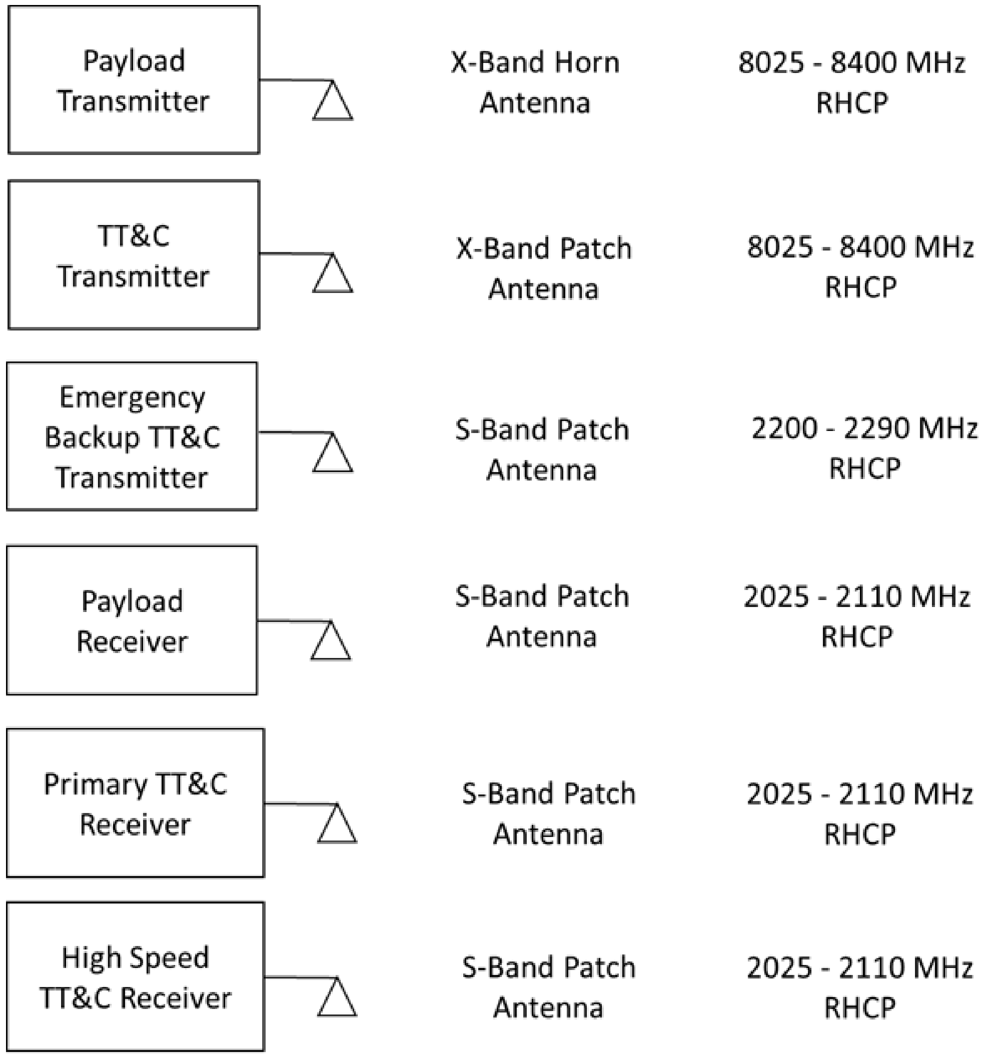

Figure 1: Communications Payload

The HE360 satellites will also receive the publicly available signals listed in Table 3.

Table 3: Receive-Only Frequencies

AIS 1 (161.9625-161.9875)
AIS 2 (162.0125-162.0375)
AIS 3 (156.7625-156.7875)
AIS 4 (156.8125-156.8375)
DSC (156.5125-156.5375)
EPIRB (406.0-406.1)
Automatic Dependent Surveillance – Broadcast (“ADS-B”) (1087.7-1092.3)

The HE360 satellites will collect and record information corresponding to the observable, environmental characteristics associated with signals of interest within the frequency ranges of the antennas aboard the spacecraft. HE360 will then downlink metadata for collected signals, including TOA, FOA, bandwidth, power, modulation type, and other similar information.

Table 4 below shows the signal tuning frequency ranges for the antennas currently planned for the HE360 Constellation.

Table 4: Signal Tuning Frequency Ranges

Antenna Types	Frequency Ranges	Gain	Intended Use
VHF Dipole	100-182 MHz	2.0 dBi	AIS processing and signal geolocation
UHF Dipole	382-422 MHz	2.0 dBi	EPIRB processing and geolocation
ADS-B Patch	1090 MHz (on frequency only)	5.0 dBi	L-band signal geolocation
L-band Patch	1.6-1.7 GHz	6.3 dBi	L-band signal geolocation
S-band Patch	2.9-3.1 GHz	7.0 dBi	S-band signal geolocation
Molded Button Antenna	1.4-7.0 GHz	5.0 dBi	Broadband spectrum scanning and monitoring; signal occupation and ID
Horn Antenna	6.0-18.0 GHz	10.4 dBi	Marine X-band RADAR and Ku-band SATCOM geolocation and

			signal metadata

III. Considerations in Support of Grant (47 C.F.R. § 25.114(d)(6))

The grant of this license will allow HE360 to develop and bring to market new products and services that contribute directly to addressing issues of public interest.[13] For example, illegal fishing is a high-profile issue of increasing concern on a global basis. Illegal fishing threatens food supplies for some of the world's most vulnerable populations and contributes to degradation of the environment. HE360's RF-based geospatial information can be used in combination with other data sources such as commercial imagery provided by third parties to identify vessels that are attempting to conceal their locations while engaging in such illegal conduct. These same capabilities will also allow development of predictive analytics products that may contribute to efforts to combat human trafficking.

Additionally, as more satellite-based communications systems are brought to market, there is an increasing premium on effective management of spectrum use and enforcement against misuse. HE360's capabilities will enable timely and cost-effective mapping of spectrum use, interference activity, and spectrum piracy, to support government regulators and private communication service providers. HE360's capabilities will also be able to provide direct support to emergency response and emergency rescue operations. For example, during hurricane events such as the ones which impacted the United States and Puerto Rico in 2017, HE360 would be able to map active cell tower pre-event and then quickly map active towers post-event

[13] Section 7 of the Communications Act (as amended), which became law in 1983, states that it is the policy of the United States "to encourage the provision of new technologies and services to the public." *See* 47 U.S.C. § 157

to provide government agencies with critical information regarding damaged communications infrastructure. Additionally, HE360 will be able to identify and geolocate EPIRB signals and rapidly feed information to first responders to help locate individuals in distress.

IV. Additional Technical Information

A. Interference Analysis

1. 8025-8400 MHz

The 8025-8400 MHz band is allocated on a primary basis internationally and in the United States for Earth Exploration Satellite Systems (ESSS) (space-to-Earth). In the United States, the 8025-8400 MHz band is allocated on a primary basis for non-Federal use, subject to a case-by-case electromagnetic compatibility analysis.[14] Transmissions from the satellites operating in this band shall not cause harmful interference to Federal and non-Federal stations operating in accordance with the U.S. Table of Frequency Allocations. HE360 will coordinate with Federal and non-Federal operators in this band to ensure compliance with these requirements.[15]

HE360 understands and includes mitigation techniques outlined in the ECC Report 115, for operating its satellite downlink in the 8025-8400 MHz band.[16] Below are the key steps taken to minimize risk of interference:

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[14] *See* 47 C.F.R. § 2.106 n.US258.
[15] *See supra* Section VI.C.5 (requesting waiver of the U.S. Table of Frequency Allocations).
[16] *See* Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administration (CEPT), *Use of the Frequency Band 8025-8400 MHz by EESS*, ECC Report 115 (Ljubljana, January 2008).

- HE360 satellites operate in a non-broadcast mode, only radiating when transmitting data to one or more of our planned earth stations.
- HE360 satellites use DSN filters to ensure no spillover into DSN operating regions.
- HE360 satellites operate well below the power flux density requirements.

(a) Interference between EESS systems operating in the band 8025-8400 MHz

Interference between the HE360 satellites and those of other systems is unlikely because EESS systems operating in the 8025-8400 MHz band normally transmit only in short periods of time while visible from the dedicated receiving Earth stations (typically less than 10 minutes for a single pass). In addition, while the beam itself is not steerable relative to the spacecraft, the transmitted beam is intentionally pointed towards the receiving Earth stations by orienting the spacecraft in the exact intended direction. HE360 satellites are designed to be non-broadcast satellites. For interference to happen, satellites belonging to different systems would have to travel through the narrow antenna beam of the receiving earth station and transmit at the same time and at same frequency. In such a very unlikely event, interference can still be avoided by coordinating the satellite transmissions so that they do not occur simultaneously. HE360 satellites provide a propulsion system which will allow additional maneuverability and phasing throughout their life. Our system design life provides 50% margin of propellant at end of life. This provides budget for orbital phasing if interference does occur. Our modulation format is OQPSK with three selectable data rates (5, 25 and 50 Mbps). This configurability allows for operation at lower bandwidths to provide another option to resolve interference if it would occur.

(b) Interference with the Fixed Service and the FSS in the band 8025-8400 MHz

Section 25.208 of the Commission's rules does not contain Power Flux Density ("PFD") limits at the Earth's surface produced by emissions from NGSO EESS space stations operating in the 8025-8400 MHz band.[17] Table 21-4 of the ITU Radio Regulations, however, states that the PFD at the Earth's surface produced by emissions from an EESS space station in the 8025-8400 MHz band, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the following values:[18]

- -150 dB(W/m^2) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -150 +0.5(d -5) dB(W/m^2) in any 4 kHz band for angles of arrival (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -140 dB(W/m2) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

These limits relate to the PFD that would be obtained under assumed free-space propagation conditions. As shown in Figure 2 and Figure 3 below, the PFDs at the Earth's surface produced by the satellite data and telemetry transmissions satisfy the PFD limits in the ITU Radio Regulations for all angles of arrival. These PFDs are based on the narrowest expected transmitter bandwidth to show the worst-case operating conditions.

[17] *See* 47 C.F.R. § 25.208.
[18] ITU Radio Regulations, Article 21, Table 21-4.

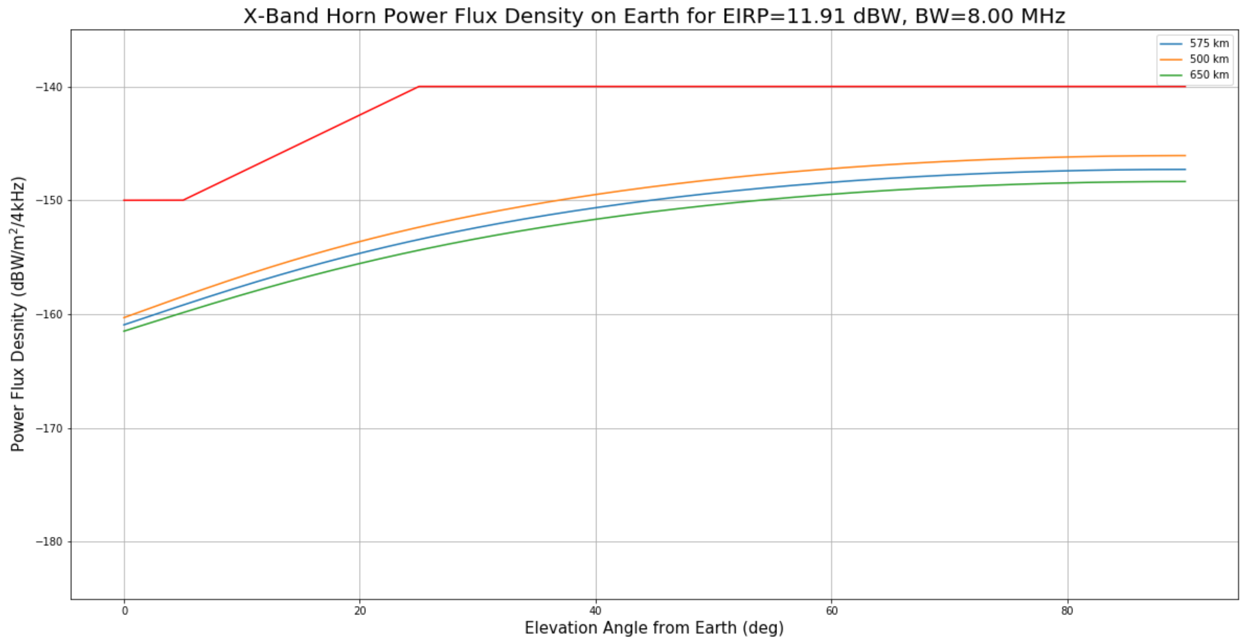

Figure 2: X-band Horn PFD at the Surface of the Earth for various orbits

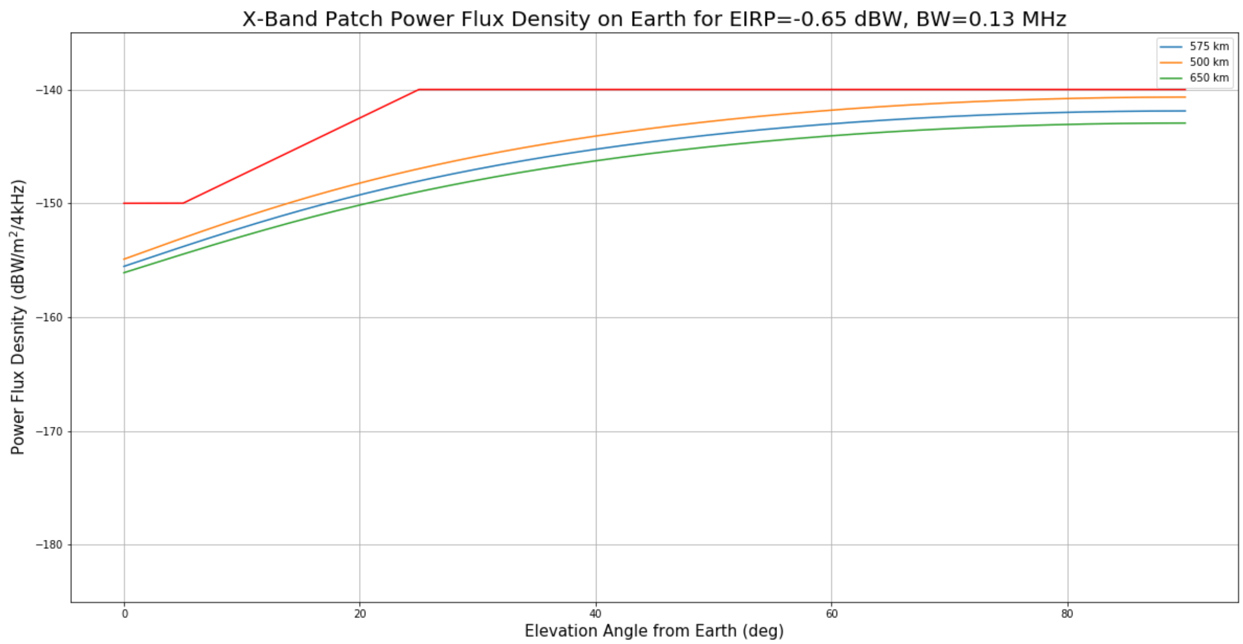

Figure 3: X-band Patch PFD at the Surface of the Earth for various orbits

(c) PFD at the Surface of the Earth in the band 8400-8450 MHz

ITU-R Recommendation SA-1157 specifies a maximum allowable interference power spectral flux-density level at the Earth's surface of -255.1 dB(W/($m^2 \cdot$Hz)) to protect ground receivers in the deep-space research band 8400-8450 MHz.[19] HE360 does not operate in this frequency range and uses DSN filters to ensure no spillover into DSN operating regions.

(d) PFD at the Geostationary Satellite Orbit

No. 22.5 of the ITU Radio Regulations specifies that in the frequency band 8025-8400 MHz, which the EESS (using non-geostationary satellites) shares with the fixed-satellite service (Earth-to-space) and the meteorological-satellite service (Earth-to-space), the maximum PFD produced at the geostationary satellite orbit ("GSO") by any EESS space station shall not exceed -174 dB(W/m^2) in any 4 kHz band.[20] The calculation below shows that the PFD produced by the transmissions from the proposed HE360 satellites does not exceed the limit in No. 22.5, even in the worst possible hypothetical case.

The PFD at the GSO produced by the HE360 transmission is:

$$PFD\ [dBW/m^2/4\ kHz] = EIRP\ (dBW) - 71 - 20\log10(D) - 10\log10(BW) - 24$$

Where:

- EIRP is the Maximum EIRP of the transmission, in dBW;
- D is distance between the HE360 satellite and GSO, in km;
- BW is the symbol bandwidth of the transmission, in MHz.

[19] Recommendation ITU-R SA.1157-1, Table 5.
[20] ITU Radio Regulations, Article 22, Section 4.

The closest distance between a HE360 satellite and the GSO is 35,786 - 650 = 35,136 km for the highest possible HE360 satellite orbit of 650 km. Under a hypothetical assumption that the HE360 satellite antenna is radiating at its peak EIRP toward the GSO, the TT&C transmission with the peak EIRP = -0.65 dBW and BW = 128 kHz produces a PFD at the GSO of -177.608 dBW/m2/4 kHz.

2. 2025-2110 MHz

The 2025-2110 MHz band is allocated on a primary basis internationally and in the United States for Federal Earth Exploration Satellite Systems (ESSS) (Earth-to-space and space-to-space).[21] In the United States, in the 2025-2110 MHz band, non-Federal Earth-to-space transmissions may be authorized in the EEES services subject to such conditions as may be applied on a case-by-case basis. Such transmissions shall not cause harmful interference to Federal and non-Federal stations operating in accordance with the Table of Frequency Allocations. HE360 will coordinate with Federal and non-Federal operators in this band to ensure compliance with this requirement.

3. 2200 - 2290 MHz

The 2200 - 2290 MHz band is allocated on a primary basis internationally and in the United States for Federal EESS (space-to-space and space-to-Earth).[22]

HE360 is using an X-Band transmitter for space-to-ground TT&C communications. In addition, HE360 will have an S-Band transmitter (2200-2290 MHz) onboard as a backup TT&C capability in the event that the X-Band transmitter fails to communicate with Earth stations as

[21] *See* 47 C.F.R. § 2.106 n.US347.
[22] *See* 47 C.F.R. § 2.106

expected on orbit. This backup S-Band transmitter would only be used in the unlikely event that communications with the X-Band transmitter fail and then would be used to communicate only with coordinated Earth stations outside the United States. Such Earth stations include the KSAT Earth station in Svalbard, Norway and possibly other non-US Earth station locations as they are added to the HE360 system in the future. HE360 will pre-coordinate with Federal operators in this band to ensure no harmful interference would be caused to their operations in the event the backup S-Band TT&C transmitter needed to be used and transmitted to non-US Earth stations.

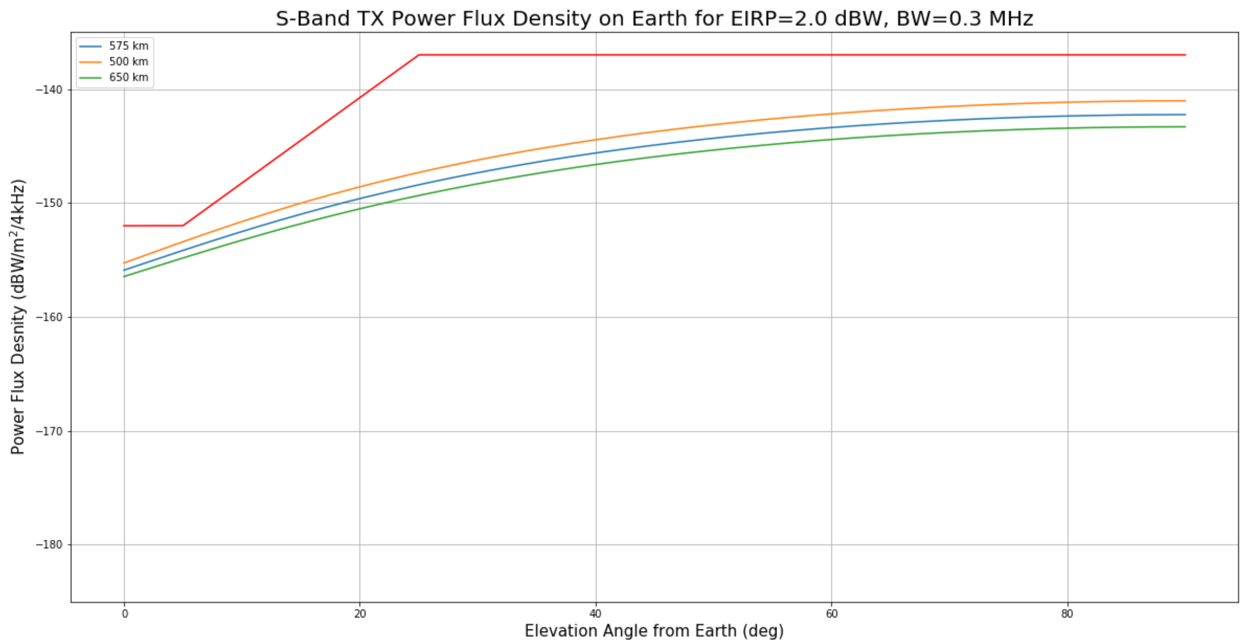

Figure 4: S-Band Patch PFD at the Surface of the Earth for various orbits

B. Link Budget

The horizon coverage area diameter from an altitude of 575 km is approximately 5,500 km. For an altitude of 650 km, it is approximately 6,400 km. The satellite transmitters are only active while communicating with the ground station. Below is the HE360 satellite link budget followed by the estimated footprint for the X-band downlink and S-band uplink, at a nominal 575 km orbital altitude.[23]

[23] The link budgets for deployment at other orbital altitudes within the 500 to 650 km range are not materially different.

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Satellite Link Budgets

Table 5: Payload Uplink Analysis

Parameter	Channel	Unit
General		
Orbit Altitude	575	km
Elevation angle	5	deg
Slant range	2,267.07	km
Frequency	2,077	MHz
Earth Station Transmitter		
Amplifier output power	14.7	W
Circuit loss	3.0	dB
Radome loss	0	dB
Antenna peak gain	36.3	dBi
Antenna HPBW	2.73	deg
EIRP	44.82	dBW
Channel Losses		
Free space loss	165.91	dB
Atmospheric loss	1.0	dB
Pointing loss	3.0	dB
Polarization loss	1.0	dB
Satellite Receiver		
Antenna gain	6.0	dBi
Antenna HPBW	90	deg
Antenna circuit loss	3.0	dB
Carrier at the antenna output	-88.47	dBm
LNA noise temperature	225.70	K
System noise temperature	1,081.04	K
Receiver noise power density (N0)	-168.26	dBm/Hz
Carrier power-to-noise density ratio (C/N0)	78.18	dBHz
Earth Station Demodulator		
Modulation	OQPSK	
Symbol rate	2000	ksps
Composite code rate	0.5	
Uncoded data rate	4000	kbit/s
Target BER	10^{-5}	
Demodulator implementation loss	1.0	dB
Required Eb/N0 at target BER	9.6	dB
Received Eb/N0	15.17	dB
Coding gain	7.50	dB
Link Margin	**12.07**	**dB**

Table 6: Payload Downlink Analysis

Parameter	Channel	Unit
General		
Orbit Altitude	575	km
Elevation angle	5	deg
Slant range	2,268.03	km
Frequency	8.175	GHz
Satellite Transmitter		
Amplifier output power	2	W
Circuit loss	1.5	dB
Antenna peak gain	10.4	dBi
Antenna HPBW	60	deg
EIRP	11.91	dBW
Channel Losses		
Free space loss	177.81	dB
Atmospheric loss	2.5	dB
Pointing loss	0.25	dB
Polarization loss	1	dB
Earth Station Receiver		
Antenna diameter	3.7	m
Antenna efficiency	0.74	%
Antenna peak gain	48.71	dBi
Antenna HPBW	0.69	deg
Radome loss	0	dB
Carrier at the antenna output	-90.69	dBm
LNA noise temperature	35.39	K
System noise temperature	159.96	K
Station G/T	26.42	dB/K
Receiver noise power density (N0)	-176.56	dBm/Hz
Carrier power-to-noise density ratio (C/N0)	85.62	dBHz
Earth Station Demodulator		
Modulation	OQPSK	
Symbol rate	50	Msps
Composite code rate	0.5	
Uncoded data rate	100	Mbit/s
Target BER	10^{-5}	
Demodulator implementation loss	1	dB
Required Eb/N0 at target BER	9.6	dB
Received Eb/N0	8.63	dB
Coding gain	5.50	dB
Link Margin	**5.53**	**dB**

Table 7: TT&C Uplink Analysis

Parameter	Channel	Unit
General		
Orbit Altitude	575	km
Elevation angle	5	deg
Slant range	2,267.07	km
Frequency	2,072	MHz
Earth Station Transmitter		
Amplifier output power	25.0	W
Circuit loss	1.5	dB
Radome loss	0	dB
Antenna peak gain	31.7	dBi
Antenna HPBW	4.22	deg
EIRP	44.22	dBW
Channel Losses		
Free space loss	165.88	dB
Atmospheric loss	1.0	dB
Pointing loss	0.0	dB
Polarization loss	1.0	dB
Satellite Receiver		
Antenna gain	6.0	dBi
Antenna HPBW	90	deg
Antenna circuit loss	3.0	dB
Carrier at the antenna output	-87.67	dBm
LNA noise temperature	169.62	K
System noise temperature	759.84	K
Receiver noise power density (N0)	-169.79	dBm/Hz
Carrier power-to-noise density ratio (C/N0)	82.12	dBHz
Earth Station Demodulator		
Modulation	GFSK	
Symbol rate	4	ksps
Composite code rate	1	
Uncoded data rate	4	kbit/s
Target BER	10^{-5}	
Demodulator implementation loss	1.0	dB
Required Eb/N0 at target BER	12.0	dB
Received Eb/N0	46.10	dB
Link Margin	**33.10**	**dB**

Table 8: TT&C Downlink Analysis

Parameter	Channel	Unit
General		
Orbit Altitude	575	km
Elevation angle	5	deg
Slant range	2,267.07	km
Frequency	8.2	GHz
Satellite Transmitter		
Amplifier output power	0.55	W
Circuit loss	2.15	dB
Antenna peak gain	4.1	dBi
Antenna HPBW	86	deg
EIRP	-0.65	dBW
Channel Losses		
Free space loss	177.84	dB
Atmospheric loss	2.5	dB
Pointing loss	0.11	dB
Polarization loss	1	dB
Earth Station Receiver		
Antenna diameter	2.4	m
Antenna efficiency	65	%
Antenna peak gain	44.42	dBi
Antenna HPBW	1.07	deg
Radome loss	0	dB
Carrier at the antenna output	-107.57	dBm
LNA noise temperature	35.39	K
System noise temperature	161.65	K
Station G/T	22.22	dB/K
Receiver noise power density (N0)	-176.52	dBm/Hz
Carrier power-to-noise density ratio (C/N0)	68.84	dBHz
Earth Station Demodulator		
Modulation	QPSK	
Symbol rate	512	ksps
Composite code rate	0.5	
Uncoded data rate	1024	kbit/s
Target BER	10^{-5}	
Demodulator implementation loss	1	dB
Required Eb/N0 at target BER	9.6	dB
Received Eb/N0	10.75	dB
Coding gain	5.10	dB
Link Margin	**5.25**	**dB**

Table 9: High Speed TT&C Uplink Analysis

Parameter	Channel	Unit
General		
Orbit Altitude	575	km
Elevation angle	5	deg
Slant range	2,267.07	km
Frequency	2,072	MHz
Earth Station Transmitter		
Amplifier output power	210.0	W
Circuit loss	1.5	dB
Radome loss	0	dB
Antenna peak gain	31.7	dBi
Antenna HPBW	4.22	deg
EIRP	53.46	dBW
Channel Losses		
Free space loss	165.88	dB
Atmospheric loss	1.0	dB
Pointing loss	0.0	dB
Polarization loss	1.0	dB
Satellite Receiver		
Antenna gain	6.0	dBi
Antenna HPBW	90	deg
Antenna circuit loss	3.5	dB
Carrier at the antenna output	-78.43	dBm
LNA noise temperature	92.29	K
System noise temperature	1,784.89	K
Receiver noise power density (N0)	-166.09	dBm/Hz
Carrier power-to-noise density ratio (C/N0)	87.65	dBHz
Earth Station Demodulator		
Modulation	GFSK	
Symbol rate	32	ksps
Target BER	10^{-5}	
Demodulator implementation loss	1.0	dB
Required Eb/N0 at target BER	12.0	dB
Received Eb/N0	42.60	dB
Link Margin	**29.60**	**dB**

Table 10: Backup TT&C Downlink Analysis

Parameter	Channel	Unit
General		
Orbit Altitude	575	km
Elevation angle	5	deg
Slant range	2,267.07	km
Frequency	2.256	GHz
Satellite Transmitter		
Amplifier output power	0.45	W
Circuit loss	0.5	dB
Antenna peak gain	6	dBi
Antenna HPBW	95	deg
EIRP	2.03	dBW
Channel Losses		
Free space loss	166.63	dB
Atmospheric loss	1	dB
Pointing loss	0.07	dB
Polarization loss	1	dB
Earth Station Receiver		
Antenna diameter	2.4	m
Antenna efficiency	65	%
Antenna peak gain	33.21	dBi
Antenna HPBW	3.88	deg
Radome loss	0	dB
Carrier at the antenna output	-103.39	dBm
LNA noise temperature	75.09	K
System noise temperature	142.26	K
Station G/T	11.60	dB/K
Receiver noise power density (N0)	-177.07	dBm/Hz
Carrier power-to-noise density ratio (C/N0)	73.61	dBHz
Earth Station Demodulator		
Modulation	QPSK	
Symbol rate	2	Msps
Composite code rate	0.5	
Uncoded data rate	4	Mbit/s
Target BER	10^{-5}	
Demodulator implementation loss	1	dB
Required Eb/N0 at target BER	9.6	dB
Received Eb/N0	9.60	dB
Coding gain	5.10	dB
Link Margin	**4.10**	**dB**

3. Antenna Patterns and Beam Contours

Antenna patterns for the X-Band horn, the S-Band patch, the X-Band patch, and crosslinks are shown in Figures 5-7 below.

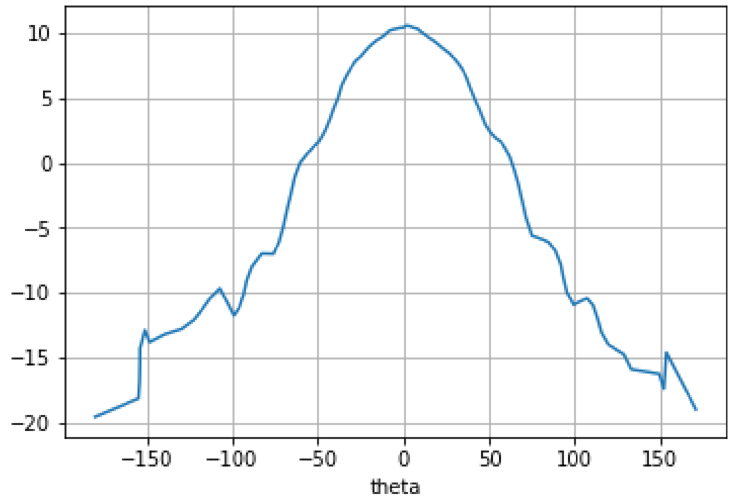

Figure 5: X-Band Horn Antenna Plot

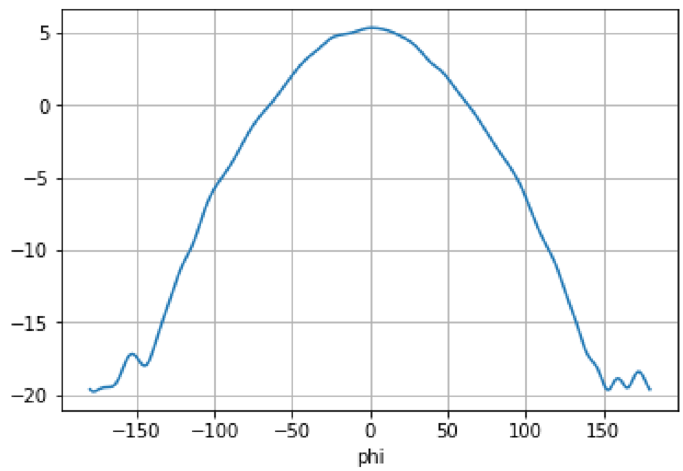

Figure 6: S-Band Patch Antenna Pattern

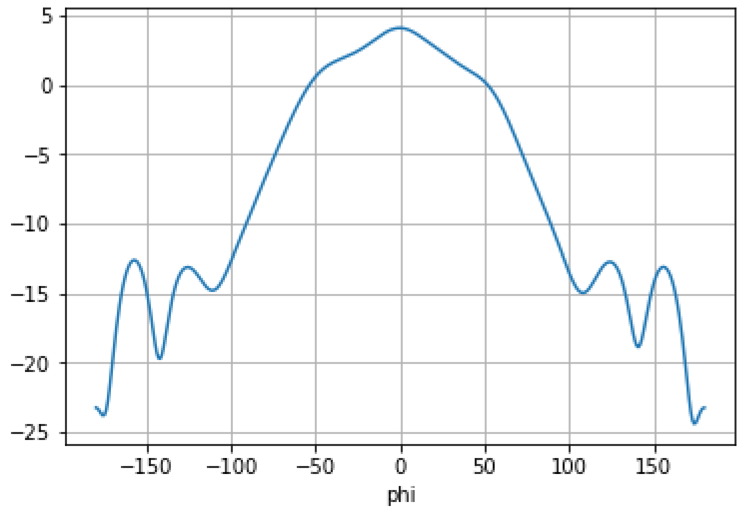

Figure 7: X-Band Patch Antenna Pattern

In Figures 5-7, beam contours are plotted at the intended 575 km altitude for the Hawk Cluster.[24] The PFDs are not materially different for the proposed orbital altitude range of deployment for the HE360 satellites.

[24] *See* 47 C.F.R. § 25.114(c)(4)(vi). Beam contours that fall beyond the edge of the visible Earth are not displayed. In a few cases where the requested contour beam interval falls beyond the edge of the visible Earth, HE360 has provided a visible contour beam as close as possible in value to the first omitted contour beam.

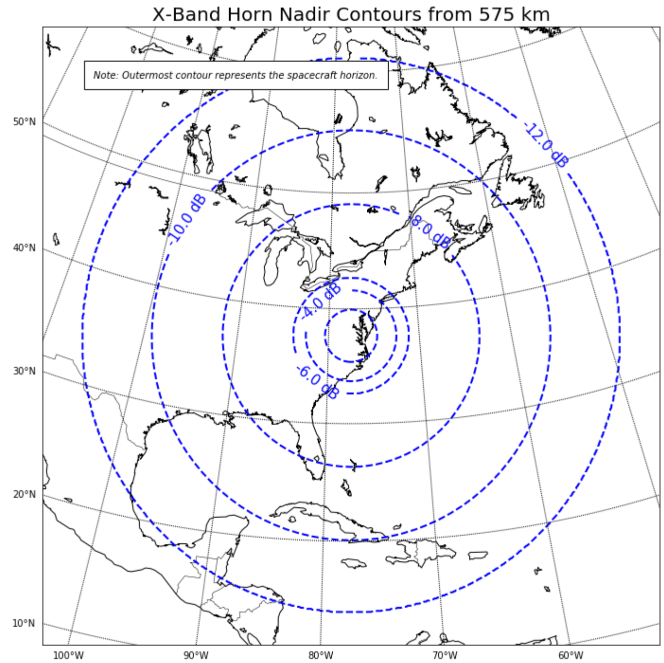

Figure 8: X-Band Horn Beam Contour

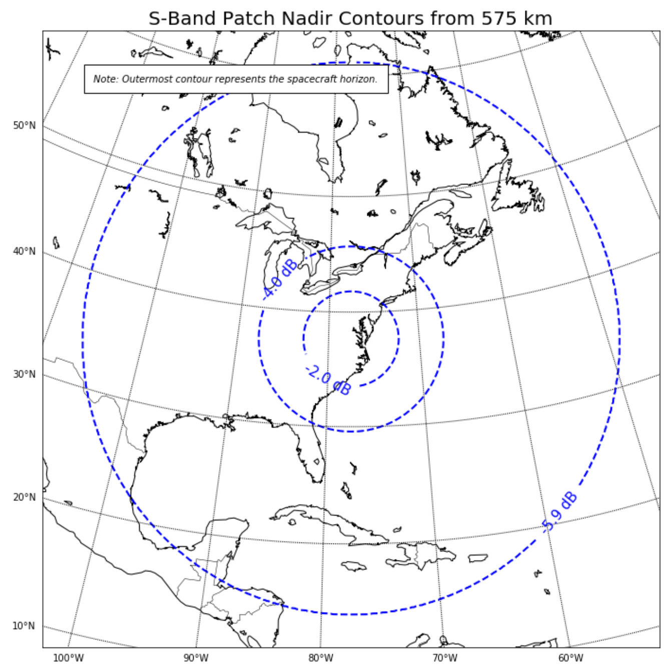

Figure 9: S-Band Patch Beam Contour

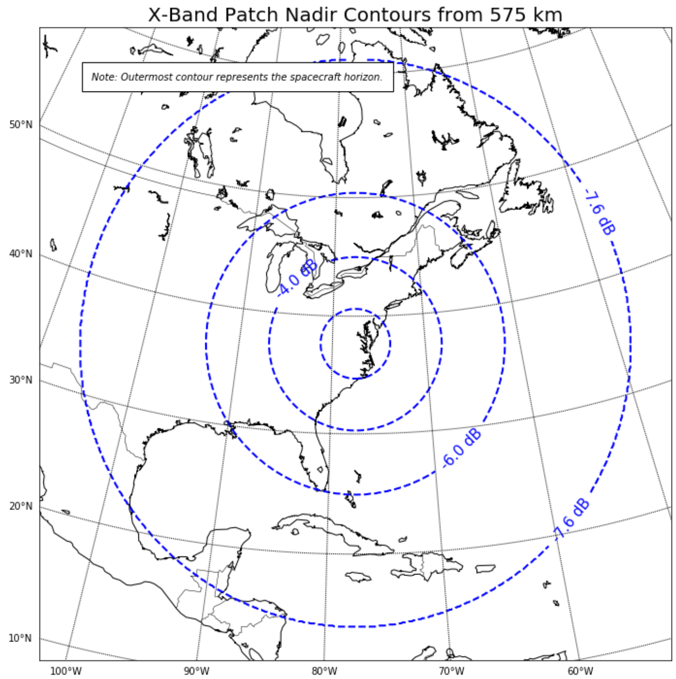

Figure 10: X-Band Patch Beam Contour

V. Orbital Debris Mitigation/ De-Orbit Plan

HE360 confirms that the Hawk satellites will not undergo any planned release of debris during their normal operations.[25] In addition, all separation and deployment mechanisms, and any other potential source of debris will be retained by the spacecraft or launch vehicle. HE360 has also assessed the probability of the space stations becoming sources of debris by collision with small debris or meteoroids of less than one centimeter in diameter that could cause loss of control and prevent post-mission disposal. HE360 has taken steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

[25] *See* 47 C.F.R. § 25.114(d)(14)(i).

HE360 has assessed and limited the probability of accidental explosions during and after completion of mission operations through a failure-mode verification analysis.[26] As part of the satellite manufacturing process, HE360 has taken steps to ensure that debris generation will not result from the conversion of energy sources on board the satellites into energy that fragments the satellites. All sources of stored energy onboard the spacecraft will have been depleted or safely contained when no longer required for mission operations or post-mission disposal.

HE360 has assessed and limited the probability of the space stations becoming a source of debris by collisions with large debris or other operational spacecraft.[27] HE360 does not intend to place any of the HE360 satellites in an orbit that is identical to or very similar to an orbit used by other space stations, and, in any event, will work closely with the cluster launch providers to ensure that the satellites are deployed in such a way as to minimize the potential for collision with any other spacecraft. This specifically includes minimizing the potential for collision with manned spacecraft.

The HE360 satellites will perform station-keeping maneuvers to maintain separation between the Hawk Cluster satellites and sustain the desired geometry as described in Section C: "Orbital Information" of this document. Typical inter-satellite distances within a Hawk Cluster will range from 125 km to 250 km and maintenance maneuvers will be conducted relatively infrequently. However, the Hawk Cluster will not maintain the satellites' inclination angles, apogees, perigees, and right ascension of the ascending node to any specified degrees of accuracy beyond the goals of maintaining the cluster geometry.

[26] *See* 47 C.F.R. § 25.114(d)(14)(ii).
[27] *See* 47 C.F.R. § 25.114(d)(14)(iii).

HE360's disclosure of the above parameters, as well as the number of space stations, the number and inclination of orbital planes, and the orbital period to be used, can assist third parties in identifying potential problems. This information also lends itself to coordination between HE360 and other operators located in similar orbits.

A detailed Orbital Debris Assessment Plan for the Polar, Mid-Latitude and Near Equatorial orbits is attached as Attachment 4.[28]

VI. Waiver Requests

The Commission may waive any of its rules if there is "good cause" to do so.[29] In general, waiver is appropriate if: (1) special circumstances warrant a deviation from the general rule; and (2) such deviation would better serve the public interest than would strict adherence to the rule.[30] Generally, the Commission will grant a waiver of its rules in a particular case if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.[31] HE360 submits that good cause exists to waive the following rules.

A. Modified Processing Round Rules

HE360 requests waiver of Sections 25.156 and 25.157 of the Commission's rules, which stipulate the processing of "NGSO-like satellite systems" under a modified processing round

[28] *See* 47 C.F.R. § 25.114(d)(14)(iv).
[29] *See* 47 C.F.R. § 1.3; *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164 (D.C. Cir. 1990); *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).
[30] *Northeast Cellular*, 897 F.2d at 1166.
[31] *WAIT Radio*, 418 F.2d at 1157.

framework.[32] Instead, HE360 requests that this application be processed pursuant to the first-come, first-served procedure adopted for "GSO-like satellite systems" under Section 25.158 of the Commission's rules.[33] The Commission has previously waived the modified processing round requirement and allowed NGSO EESS systems to be processed on a first-come, first-served basis and should do so here.[34]

The HE360 Constellation meets the definition of EESS, which both the ITU and FCC rules define as a radiocommunication service in which "information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, is obtained from active sensors or passive sensors on Earth satellites."[35] The HE360 Constellation senses and analyzes natural and manmade electromagnetic radiation from and surrounding the Earth and electron content in the ionosphere.[36]

Further, from a communications perspective, the HE360 system is functionally similar to other EESS systems. The HE360 satellites observe and record data originating from or surrounding the Earth and downlink such data to Earth stations that are part of the satellite network, like other EESS systems. Spectrum sharing will be possible because the satellites forming the HE360 Constellation and satellites in other similar systems transmit/receive only in

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[32] *See* 47 C.F.R. §§ 25.156, 25.157.
[33] *See* 47 C.F.R. § 25.158.
[34] *See* Stamp Grant, Planet Labs, Inc., SAT-LOA-20130626-00087 (granted Dec. 3, 2013) ("Planet Labs Stamp Grant"); Stamp Grant, Skybox Imaging, Inc., SAT-LOA-20120322-00058 (granted Sept. 9, 2012); *Space Imaging, LLC*, Declaratory Order and Order and Authorization, 20 FCC Rcd 11964 ¶¶ 9-11 (2005) ("*Space Imaging Order*").
[35] *See* ITU RR 1.51; 47 C.F.R. § 2.1. The rules also note that similar information is collected from airborne or Earth-based platforms, as is the case here. *See* ITU RR 1.51; 47 C.F.R. § 2.1.
[36] *See supra* Section II.B.2, Products and Services.

short periods of time while visible to a receiving/transmitting earth station. For harmful interference to occur, satellites belonging to the different systems would have to be visible to the earth station and transmitting or receiving using the same frequencies at the exact same time. In such an unlikely event, the resulting interference could be avoided by coordinating the satellite transmissions so that they do not occur simultaneously. Accordingly, there is no mutual exclusivity between the HE360 Constellation and other NGSO EESS systems using the same frequency band.

Because the purpose of the modified processing round is to preserve opportunities for competitive entry in frequency bands where licensing the first applicant to operate in the band would prevent subsequent applicants from using the spectrum, grant of the waiver would not undermine the rules.[37] Accordingly, waiving Sections 25.156 and 25.157 will not undermine the policy objectives of these rules, and the waiver request is justified here.

B. Waiver Request of Default Service Rules

HE360 requests a waiver of the default service rules under Section 25.217(b) of the Commission's rules.[38] The Commission has not adopted band-specific rules for the services HE360 proposes to provide. Additionally, the Commission has previously granted a waiver of the default service rules to NGSO EESS applicants, based on the fact that the operators are required to comply with technical requirements in Part 2 of the Commission's rules and

[37] *See*, *e.g.*, *Space Imaging Order* 20 FCC Rcd ¶ 10.
[38] *See* 47 C.F.R. § 25.217(b); *see also* 47 C.F.R. §§ 25.156, 25.157.

applicable ITU rules.[39] In these cases, the Commission concluded that, because the cited requirements had been sufficient to prevent harmful interference, there was no need to impose additional technical requirements on operations in that band and, therefore, granted the waiver requests. These same reasons warrant waiver of the default service rules here.

C. Waiver Requests of the U.S. Table of Frequency Allocations

1. 2025-2110 MHz (Earth-to-Space) Primary Data and TT&C Uplink

This band is allocated to EESS subject to conditions as may be applied on a case-by-case basis and not causing harmful interference to authorized Federal and non-Federal operations.[40] As discussed above, HE360 proposed services meet the definition of EESS, and accordingly, the HE360 Constellation may use this frequency band consistent with the U.S. Table of Frequency Allocations.[41] Nonetheless, to the extent necessary, HE360 requests a waiver of the U.S. Table of Frequency Allocations in the event the Commission concludes that the HE360 system is not an EESS system.

2. 8025-8400 MHz (Space-to-Earth) Primary Data and TT&C Downlink

This band is allocated to EESS on a primary basis.[42] As discussed above, HE360 proposed services meet the definition of EESS, and accordingly, the HE360 Constellation may

[39] *See Space Imaging Order*, 20 FCC Rcd ¶¶ 26-31; *DigitalGlobe, Inc.*, Order and Authorization, 20 FCC Rcd 15696 ¶¶ 1, 15 (2005); *see also* Planet Labs Stamp Grant; Skybox Imaging Stamp Grant; Spire Global Inc., SAT-LOA-20151123-00078 (granted in part Mar. 18, 2016) ("Spire Global March 2016 Stamp Grant").
[40] 47 C.F.R. § 2.106 n.US347.
[41] *See supra* Section VI.A
[42] 47 C.F.R. § 2.106 n.US258.

use this frequency band consistent with the U.S. Table of Frequency Allocations.[43] Nonetheless, to the extent necessary, HE360 requests a waiver of the U.S. Table of Frequency Allocations in the event the Commission concludes that the HE360 system is not an EESS system.

3. 2200-2290 MHz (Space-to-Earth) Backup TT&C Downlink

HE360 requests a waiver of the U.S. Table of Frequency Allocations to use the 2200-2290 MHz band (space-to-Earth) as a backup TT&C downlink on a non-conforming, non-harmful interference basis.[44] This band is allocated to Space Ops (space-to-Earth) and EESS (space-to-Earth) on a co-primary basis across all ITU regions. In the U.S., this band is allocated only for Federal use.[45]

HE360 will have an S-Band transmitter (2200-2290 MHz) onboard as a backup TT&C capability in the event the X-Band transmitter fails to communicate with Earth stations. This backup S-Band transmitter would only be used in the unlikely event that communications with the X-Band transmitter fails and then would be used only to communicate with coordinated Earth stations outside the United States.[46] Such Earth stations include the KSAT Earth station in Svalbard, Norway and possibly other non-US Earth station locations as they are added to the HE360 system in the future. HE360 will coordinate use of this band with NTIA prior to use.

4. Receive-Only Frequencies

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[43] *See supra* Section VI.A

[44] *See* 47 C.F.R. §§ 2.102(a), 2.106.

[45] *See* 47 C.F.R. § 2.106 nn.5.392, US303.

[46] HE360 does not in the application seek authority to communicate in the 2200-2290 MHz band with Earth stations located in the United States. In the future, if HE360 were to seek any such authority, it would do so pursuant to Special Temporary Authority as discussed with NTIA.

(a) ADS-B (1087.7-1092.3 MHz)

The 1087.7-1092.3 MHz band is allocated to the Aeronautical Mobile (R) and Aeronautical Radionavigation service on a co-primary basis in the U.S. Table of Frequency Allocations.[47] At the WRC-15, this band was allocated internationally for the aeronautical mobile-satellite (R) service on a primary basis and is limited to the space station reception of ADS-B emissions from aircraft transmitters that operate in accordance with recognized international aeronautical standards.[48] HE360 requests waiver of the U.S. Table of Frequency Allocations to allow satellite reception of ADS-B signals.

HE360 would only receive the signals and therefore could not cause harmful interference. HE360 understands that it shall not claim protection from stations operating in the aeronautical radionavigation service.[49]

Accordingly, grant of the waiver would not undermine the service allocations in the U.S. Table of Frequency Allocations.[50] Additionally, the FCC has previously granted the same request by another operator.[51]

(b) Emergency Position Indicating Radio Beacon (406.0-406.1 MHz).

The 406.0-406.1 MHz band is allocated for Mobile-Satellite Service ("MSS") and limited to low-power satellite emergency position-indicating radio beacons.[52] HE360's proposed

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[47] *See* 47 C.F.R. § 2.106.
[48] *See* ITU Resolution 425 (WRC-15).
[49] Any future protection of ADS-B reception will be governed by any changes to the relevant status in the U.S. Table of Frequency Allocations.
[50] *See Iridium Order* ¶ 21 (granting waiver of U.S. Table of Frequency Allocations to permit satellite reception of AIS 3 and AIS 4 signals).
[51] *See* Stamp Grant, Spire Global, Inc., SAT-AMD-20161114-00107 (granted in part April 7, 2017) ("Spire Global April 2017 Stamp Grant").

satellite reception of EPIRB signals is consistent with this allocation. Nonetheless, to the extent necessary, HE360 requests waiver of the Commission's rules to allow HE360's proposed reception of EPIRB signals for its system.

HE360 proposes only receive-only use of the signal and the FCC has consistently concluded that such use cannot cause harmful interference.[53] Moreover, HE360's reception of EPIRB signals would serve the public interest by providing near real-time emergency location information of interest to government and commercial users.

The EPIRB signal is currently monitored by the COSPAS-SARSAT architecture, administered by NOAA and several international partners. This system uses a combination of geostationary and low earth orbit satellites (GEOSAR and LEOSAR, respectively) to monitor and geolocate EPIRB distress signals. The GEOSAR component of the architecture provides continuous monitoring of most of the globe, except for both polar regions, but cannot produce independent geolocation of beacons and so must rely on the beacon's self-reported location (which can often be inaccurate by hundreds or thousands of kilometers, especially in the case of older beacons). Alternatively, geolocation can be provided by the LEOSAR component, which can use doppler processing to produce independent geolocations which have a typical accuracy of approximately 4 km.

The LEOSAR satellites operate in a polar orbit, which provides global coverage but at latencies of up to 6 hours depending on the location of the beacon. Both LEOSAR and

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[52] *See* 47 C.F.R. § 2.106 n.5.266.
[53] *See Iridium Order* ¶ 21; *see also* Spire Global April 2017 Stamp Grant (granting request for satellite reception of AIS 1, AIS 2, AIS 3, AIS 4, ASM 1, ASM 2, and ADS-B signals).

GEOSAR are aging components of the global search and rescue system, and an updated architecture dubbed MEOSAR is currently being deployed. This updated architecture consists of payloads hosted on GPS-III, GALILEO, and GLONASS GNSS satellites. Because the MEOSAR payloads launch according to the schedule constraints of the host platforms, full operational capability ("FOC") of this system is not projected to occur until 2025-2035.

HE360's EPIRB monitoring and geolocation capability is currently being evaluated by a government customer as a potential augmentation to the existing COSPAS-SARSAT architecture by decreasing response times for emergencies in the polar regions. Simulations and airborne demonstrations have shown that HE360-produced geolocations may be as accurate as 500 m or better and will be available with very low latency for polar regions. Additionally, the HE360 system may be able to provide support to the architecture as a gap filler to provide coverage before MEOSAR reaches FOC. For the above reasons, the FCC should grant the waiver request.

(c) AIS 1 (161.9625-161.9875 MHz) and AIS 2 (162.0125-162.0375 MHz)

To the extent necessary, HE360 requests waiver of the Commission's rules to permit reception of AIS 1 and AIS 2 signals by the HE360 Constellation. AIS 1 (161.9625-161.9875 MHz) and AIS 2 (162.0125-162.0375 MHz) are allocated to the Maritime Mobile (Earth-to-space), Aeronautical Mobile (OR), and MSS (Earth-to-space) on a co-primary basis, with MSS being limited for the purposes of reception of AIS emissions.[54] HE360's proposed use of these bands for satellite receive-only purposes is in accordance with the U.S. Table of Frequency Allocations. Indeed, the FCC has approved the reception of these bands by other satellite

[54] *See* 47 C.F.R. § 2.106, n. US52.

applicants.[55] For these reasons, to the extent necessary, the FCC should grant this waiver request for the reception of AIS 1 and AIS 2 signals by the HE360 Constellation.

(d) AIS 3 (156.7625-156.7875 MHz) and AIS 4 (156.8125-156.8375 MHz)

AIS 3 (156.7625-156.7875 MHz) and AIS 4 (156.8125-156.8375 MHz) are allocated to Maritime Mobile (distress, urgency, safety and calling) and MSS (Earth-to-space) in all ITU Regions on a co-primary basis, with MSS being limited for the purposes of reception of AIS emissions.[56] The Commission has proposed but not yet adopted an MSS (Earth-to-space) allocation for AIS 3 and AIS 4.[57]

HE360 requests waiver of the U.S. Table of Frequency Allocations to allow the HE360 Constellation to receive AIS 3 and AIS 4 signals on a non-conforming, non-harmful interference basis until the bands are allocated in the U.S. Table of Frequency Allocations, after which HE360's proposed reception of AIS 3 and AIS 4 signals should be treated as conforming and authorized consistent with the U.S. Table of Frequency Allocations. Grant of this waiver is consistent with FCC precedent approving the reception of these bands by other satellite applicants.[58] Moreover, grant of the waiver serves the public interest by providing critical near real-time maritime data of interest to government and commercial users.[59]

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[55] *See, e.g.*, Spire Global March 2016 Stamp Grant.
[56] *See* 47 C.F.R. § 2.106, n.US52.
[57] *See Implementation of World Radiocommunication Conferences WRC 07 and WRC 12*, Report and Order, Order, and Notice of Proposed Rulemaking, 30 FCC Rcd 4183 ¶¶ 202-05 (2015).
[58] The FCC has approved such use because use of these bands will be receive only and therefore cannot cause harmful interference and because the presence of the signals will be present regardless of the reception by the satellite applicant. *See, e.g.*, *Iridium Order* ¶ 21; Spire Global March 2016 Stamp Grant.
[59] *See* Spire Global March 2016 Stamp Grant.

HE360 recognizes that, as a condition of this waiver: (i) it must not claim protection for reception of messages in these bands that is not in accordance with the U.S. Table of Frequency Allocations for the pertinent area; and (ii) it may only claim protection to the extent provided by the status of the reception under the U.S. Table of Frequency Allocations.[60] Further, HE360 understands that all reception in this band must comport with the requirements on unauthorized publication or use of communications in Section 605 of the Communications Act of 1934, as amended.[61]

(e) DSC (156.5125-156.5375 MHz)

Digital Selective Calling ("DSC") is a maritime communication protocol that is a part of the Global Maritime Distress and Safety System or GMDSS. The frequency is allocated to Maritime Mobile (distress, urgency, safety and calling via DSC) in all ITU Regions on a primary basis.[62]

HE360 requests waiver of the U.S. Table of Frequency Allocations to allow its constellation to receive the DSC signal on a non-conforming, non-harmful interference basis. Grant of this waiver is consistent with FCC precedent approving the reception of similar frequency bands by other satellite applicants.[63] Moreover, grant of the waiver serves the public

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[60] *See Iridium Order* ¶ 21.

[61] *See* 47 U.S.C. § 605; *see also Iridium Order* ¶ 21.

[62] *See* 47 C.F.R. § 2.106, nn. 5.111, 5.266, and US266. In the United States, there is also limited use of this band by certain grandfathered public safety radio pool licensees.

[63] The FCC has approved such use because use of these bands will be receive only and therefore cannot cause harmful interference and because the presence of the signals will be present regardless of the reception by the satellite applicant. *See, e.g., Iridium Order* ¶ 21; Spire Global March 2016 Stamp Grant.

interest by providing critical near real-time maritime safety data of interest to government and commercial users.[64]

HE360 recognizes that, as a condition of this waiver: (i) it must not claim protection for reception of messages in these bands that is not in accordance with the U.S. Table of Frequency Allocations for the pertinent area; and (ii) it may only claim protection to the extent provided by the status of the reception under the U.S. Table of Frequency Allocations.[65] Further, HE360 understands that all reception in this band must comport with the requirements on unauthorized publication or use of communications in Section 605 of the Communications Act of 1934, as amended.[66]

D. Waiver of Schedule S Requirements

HE360 requests a limited waiver of Section 25.114(c) of the Commission's rules, which requires certain information to be filed in the Schedule S. Schedule S requests orbital information for all satellites. Given HE360's status as a secondary payload customer, HE360 cannot practicably provide this information.[67] HE360 has provided representative data that will allow the Commission to conduct an accurate technical assessment of the planned HE360 Constellation. Strict application of the rules here is unnecessary to serve the purposes of the rules, which is to ensure that the Commission has all the relevant information to evaluate the

[64] *See* Spire Global March 2016 Stamp Grant.
[65] *See Iridium Order* ¶ 21.
[66] *See* 47 U.S.C. § 605; *see also Iridium Order* ¶ 21.
[67] *See* FCC Form 312 Schedule S, Tables S4-S5.

application. Given that HE360 has provided all relevant information in the narrative and Schedule S, waiver of the certain Schedule S requirements is appropriate.[68]

HE360's TT&C X-Band transmitter (Beam ID: "TCXD") has a Max Transmit EIRP of -0.65. However the Schedule S data field will not accept a number less than zero. HE360 entered zero to satisfy the Schedule S form requirement that maximum EIRP values be non-negative. Accordingly, with respect to this entry in the Schedule S, HE360 requests a waiver of the FCC's requirement to provide accurate information.

E. Waiver of Bond Requirements

HE360 requests waiver of the FCC's milestone and bond requirements for NGSO systems.[69] HE360 anticipates launch for its first Hawk Cluster (of three satellites) for the HE360 Constellation in Q4 2019. Additional satellites are expected to be deployed every four to six months thereafter. Moreover, HE360 does not seek mutually exclusive use of the spectrum, as discussed above.[70] Accordingly, there can be no concerns about speculation or spectrum warehousing.

In similar situations for other EESS providers, the Commission has waived the milestone and bond requirements and conditioned such licenses on the authorization becoming null and

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[68] *See* 47 C.F.R. § 1.3; *see, e.g.*, Stamp Grant, ViaSat, Inc., SAT-LOI-20140204-00013 (granted Jun. 18, 2014) (waiving Schedule S requirements because they were found to be unnecessary for the space station application)
[69] *See* 47 C.F.R. §§ 25.164, 25.165.
[70] *See* VI.A above, Modified Processing Rules.

void if at any time after the initial deployment of satellites there are no satellites operating as part of the authorized constellation.[71] HE360 would accept a license grant with such a condition.

The public interest would be served by waiver of the milestone and bond requirements. As the Commission is aware, the magnitude of the bond amount was established based on the cost of manufacturing and deploying more traditional satellite systems, which the Commission estimated in the hundreds of millions of dollars for geostationary satellite systems and more for non-geostationary satellite systems.[72] In contrast, the cost of deploying a smallsat system, such as the one proposed by HE360, would be orders of magnitude less. Thus, the imposition of a bond requirement would impose a material, disproportionate burden on applicants for innovative smallsat systems. In the event the FCC denies this waiver request, HE360 affirms that it will comply with the bond requirement.

VII. ITU Materials and Cost Recovery

HE360 has prepared the ITU Advance Publication Information submission for its proposed system, including the ITU Appendix 4 notification using SpaceCap software and will provide this information to the Commission under separate cover. HE360 is submitting a commitment to pay in an ITU Cost Recovery letter.

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[71] *See*, e.g., Application of Planet Labs Inc. for Modification of Authority to Launch and Operate an NGSO Satellite System (call sign S2912), IBFS No. SAT-MOD-20150802-00053, at Conditions 12-13 (granted June 15, 2016); Application of Spire Global, Inc. for Authority to Launch and Operate an NGSO Satellite System (call sign S2946), IBFS No. SAT-LOA-20151123-00078, at Conditions 6-7 (granted June 16, 2016).

[72] *See Amendment of the Commission's Space Station Licensing Rules and Policies*, Notice of Proposed Rulemaking and First Report and Order, 17 FCC Rcd 3847 ¶ 112 (2002); *Amendment of the Commission's Space Station Licensing Rules and Policies*, First Report and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 10760 ¶ 168 (2003).

VIII. Conclusion

HE360 respectfully requests the Commission to grant the application for launch and operation authority as detailed herein.

Respectfully submitted,

/s/Rob Rainhart

Robert Rainhart
Senior Vice President, Engineering and Product

HawkEye 360, Inc.
196 Van Buren Street #450
Herndon, Virginia 20171