ICEYE US, Inc.
File No. SAT-LOA-20210212-00021
Response to FCC Follow-Up Questions
April 1, 2021

On February 12, 2021, ICEYE US, Inc. (ICEYE) filed the above-referenced application pursuant to the streamlined small satellite licensing procedures, requesting authority to launch, deploy, and operate six satellites that would operate in the Earth-Exploration Satellite Service (EESS), conducting synthetic aperture radar (SAR) imaging.

Please provide the following additional information in order to assist in the Commission's review of this application:

1. Please clarify whether all space stations in the planned constellation will be technically identical.

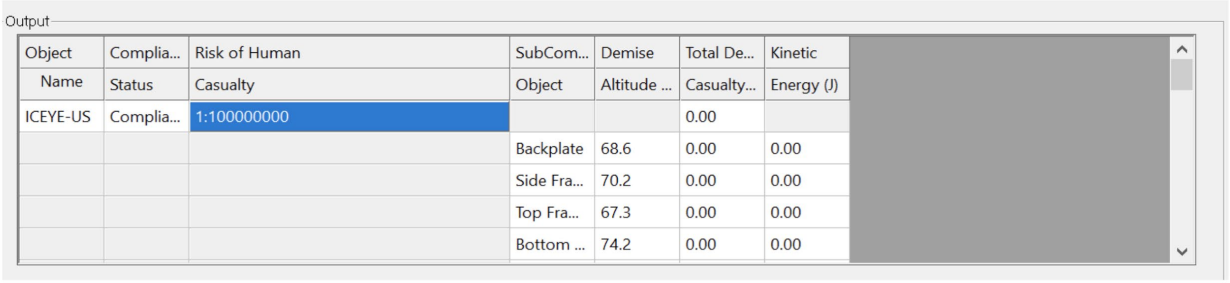
All spacecraft will be technically identical.

2. Please provide antenna gain contours for each transmit and receive antenna beam, as required by Section 25.114(c)(vi)(B) of the Commission's rules, 47 CFR § 25.114(c)(vi)(B).

Please see Exhibit B to ICEYE's initial filing, Figures 2, 3 and 4.

3. Please clarify the risk of casualty associated with the space stations' atmospheric re-entry. In the Narrative Statement, ICEYE states that the requirements for streamlined processing are met for all space stations in the planned system, including the requirement that the risk of human casualty is zero as calculated using the NASA DAS or higher fidelity model. However, in the Orbital Debris Assessment Report (ODAR), ICEYE indicates that the "DAS program outputs" demonstrate a risk of human casualty is 1:65,800. ICEYE also states that no objects are expected to survive reentry, which is inconsistent with a risk of human casualty of 1:65,800. Please clarify whether there is debris that would be expected to survive atmospheric re-entry as evaluated under the DAS, and if so, please provide, at a minimum, the component name, material, mass, and surviving kinetic energy. Alternatively, please provide the complete DAS logs for the survivability requirement analysis.

The complete DAS logs for the survivability requirement analysis are attached as Exhibit 1. In summary, these logs show a 1 in 100,000,000 million risk of human casualty.



Output

Object Name	Complia... Status	Risk of Human Casualty	SubCom... Object	Demise Altitude ...	Total De... Casualty...	Kinetic Energy (J)
ICEYE-US	Complia...	1:100000000			0.00	
			Backplate	68.6	0.00	0.00
			Side Fra...	70.2	0.00	0.00
			Top Fra...	67.3	0.00	0.00
			Bottom ...	74.2	0.00	0.00

4. ICEYE states that "[p]ropulsion will be utilized for station-keeping and collision avoidance maneuvers." Please provide additional information regarding the expected station-keeping tolerances of the space stations (+/- altitude, inclination, etc.).

The expected station-keeping tolerance of the space stations is +/- 2 km of operational altitude. ICEYE will coordinate and exchange information with the 18th Space Control Squadron on both position and planned maneuvers.

5. ICEYE states that the "satellite bus has a total mass of less than 150 kilograms, including propellant." Please provide the mass of the satellite bus without propellant. Also, please explain how the amount of propellant was factored into DAS end-of-life calculations.

The mass of the satellite bus without propellant is 89.1 kilograms. The propellant adds an additional 0.6 kilograms, for a gross mass of 89.7 kilograms at launch. The attached DAS logs show that both values were used in end-of-life calculations. The remaining propellant, together with the spacecraft, burns up during de-orbiting.

6. ICEYE states that the space stations use a solid metal propellant. What is the solid metal being used as propellant?

Indium

7. ICEYE states that it "has utilized NASA's DAS to assess the probability of a collision with objects larger than 10 centimeters in diameter, and found the probability of collision to be 0.00002." Please clarify whether the 0.00002 collision risk was calculated per satellite, or whether it is represents the total risk for the six-satellite system.

The collision risk was calculated per satellite.

8. Please provide a statement in response to Section 25.122(d)(5) of the Commission's rules, which requires a description of the design and operational strategies that will be used to avoid in-orbit collision with spacecraft capable of having crew aboard. For example, what operational strategies will ICEYE use while de-orbiting the space stations through the International Space Station altitude?

The spacecraft will operate at an orbital altitude of 550 km. The International Space Station operates at an average orbital altitude of 400 km. ICEYE will coordinate with the 18th Space Control Squadron on both position and planned maneuvers, including de-orbiting.

9. International Telecommunication Union Radio Regulations (ITU RR) 22.5 provides that, in the 8025-8400 MHz frequency band shared by EESS using non-geostationary orbit satellites with the fixed-satellite service (Earth-to-space) or the meteorological-satellite service (Earth-to-space), the maximum power flux-density produced at the geostationary-satellite orbit by EESS space station will not exceed −174 dB(W/m2) in any 4 kHz band. Please address how ICEYE will comply with ITU RR 22.5.

ICEYE spacecraft will transmit only in the space-to-earth direction, and therefore, will not exceed the maximum power flux-density requirement at the geostationary satellite orbit, which is 21,750 km higher than ICEYE's orbit.

10. ITU RR SA.1157 specifies protection criteria for deep space earth station receivers in the 8400-8450 MHz band with PSD limited to -221 dBW/Hz at the inputs of deep space earth station receivers. Please address how ICEYE will comply with ITU RR SA.1157.

ICEYE spacecraft will not operate in the 8400 – 8450 MHz band. In all events, ICEYE will use a Deep Space Network (DSN) filter to ensure compliance with ITU RR SA.1157.

11. ICEYE has acknowledged that it will need to coordinate with co-frequency Federal and non-Federal earth station operators. Please provide a status update regarding such coordination efforts.

ICEYE acknowledged that it will need to coordinate the use of any non-U.S. ground station with co-frequency Federal earth station operators in the 2200 – 2290 MHz downlink band; the 8025 – 8400 MHz downlink band; and the 2025 – 2100 MHz uplink band. ICEYE will notify NTIA at least 14 days prior to the use of any non-U.S. ground station operating in these bands.

12. ITU-R RS.1280 provides guidance on maximizing compatibility between spaceborne and terrestrial radar systems, as well as a methodology for assessing whether the peak or average power of an active spaceborne sensor exceeds that of the example terrestrial sensors provided in the recommendation. Please address how ICEYE will comply with the guidance specified in ITU-R RS.1280.

The design of ICEYE's spaceborne radar system was carefully evaluated to fulfill the requirements in ITU-R RS.1280. Transmitter power, antenna gain (particularly sidelobe levels), pulse width and repetition rate, and chirp bandwidth are all adjusted to ensure compliance with ITU-R RS.1280.
Furthermore, ICEYE can adjust power levels while the spacecraft is in orbit, thus enabling ICEYE to reduce such power levels if necessary to eliminate harmful interference to terrestrial radar systems.

13. Regarding operations in the 9300-9900 MHz frequency range, ITU RS.2094 states a particular interference mitigation technique may reduce interference caused by SAR antennas. Please provide a description of any mitigation techniques you will be employing in the 9300-9900 MHz range.

ICEYE's network operations center will perform Doppler processing on the received signal, which will enable marking dissimilar pulsed signals across a number of Doppler bins, resulting in an averaged interfering signal level. ICEYE then will use average SAR power rather than peak power in order to reduce potential interference levels.

14. Concerning use of the 9300-9900 MHz frequency band in the space-to-Earth direction, considering that the band is allocated on a secondary basis for non-Federal operations in the U.S. Table of Allocations, 47 CFR § 2.106, please provide any additional information to elaborate on how the planned satellite network will operate on a non-harmful interference basis with respect to the primary allocated services.

The ICEYE spacecraft sensor bandwidth in the 9300 – 9900 MHz band will not exceed 600 megahertz and any transmissions will consist of frequency diverse chirp signals. By the nature of the spacecraft's motion, these signals will be both brief and transitory on the ground and highly unlikely to be interpreted as a valid response or interrogation to a ground-based system. Regardless, ICEYE will operate its spacecraft on a secondary basis and will not seek protection from primary service users. In the event of any harmful interference, ICEYE will work with the primary user to eliminate harmful interference, including, if necessary, agreeing not to transmit within the affected ground area.

15. ICEYE states that it will provide "the appropriate electronic files for submission to the ITU." Please provide those files or provide an update on the status of the preparation of those files.

ICEYE is currently preparing an ITU application, and expects to submit that application on or before April 7, 2021.