Supplement Exhibit: Orbital Debris and L-band Transceivers

Cryptosat herein provides additional information regarding the Crypto3 satellite pursuant to Section 5.64 of the Commission's rules, and regarding the performance characteristics of the Iridium L-band transceivers at the request of Commission staff.

§ 5.64 Special provisions for satellite systems.

5.64 Language	Cryptosat's Response
(a) Construction of proposed experimental satellite facilities may begin prior to Commission grant of an authorization. Such construction is entirely at the applicant's risk and does not entitle the applicant to any assurances that its proposed experiment will be subsequently approved or regular services subsequently authorized. The applicant must notify the Commission's Office of Engineering and Technology in writing that it plans to begin construction at its own risk.	
(b) Except where the satellite system has already been authorized by the FCC, applicants for an experimental authorization involving a satellite system must submit a description of the design and operational strategies the satellite system will use to mitigate orbital debris, including the following information:	
(1) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices, distinct from the space station launch vehicle, that may become a source of orbital debris;	No debris is planned to be released during nominal operations.

5.64 Language	Cryptosat's Response
(2) A statement indicating whether the space station operator has assessed and limited the probability that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;	DAS analysis has not yet been completed. None of the Crypto3 components are vital to post-mission disposal. Crypto3 will naturally decay and re-enter the Earth's atmosphere at end of life without the need of active control. Loss of control will not prevent disposal.
(3) A statement that the space station operator has assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;	The only energy source (kinetic, chemical, or otherwise) onboard the spacecraft is a Lithium Ion battery system. **Summary of failure modes and effects analysis of all credible failure modes, which may lead to an accidental explosion:** Crypto3 contains one four cell Lithium Ion (4S1P) battery pack (NCR18650B). The battery was designed, fabricated, and tested by Innovative Solutions in Space. The battery represents the only credible failure mode during which stored energy is released. The main failure modes associated with Lithium Ion batteries result from overcharging, over-discharging, internal shorts, and external shorts. **Risk Mitigation Plan:** The battery has been designed and built to mitigate the chance of any accidental venting or explosion caused by the above failure modes. Crypto3 does not contain any propellant or liquids. Any stored energy will be removed at the spacecraft's end of life by leaving all batteries in a permanent discharge state.

5.64 Language	Cryptosat's Response
(4) A statement that the space station operator has assessed and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations. (i) Where the application is for an NGSO space station or system, the following information must also be included:	DAS analysis has not yet been performed.
(A) A demonstration that the space station operator has assessed and limited the probability of collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.	DAS analysis has not yet been performed.
(B) The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision.	Cryptosat has and will engage with operators of nearby constellations and other space stations to ensure safe and coordinated space operations, as necessary. Cryptosat has and will continue to provide all relevant agencies with any information they need to assess risks and ensure safe flight profiles. Cryptosat has provided contact information for its Mission Control Center personnel.
(C) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.	Cryptosat will coordinate with NASA to ensure protection of the International Space Station and with the China National Space Agency with respect to Tiangong-2 and successor vehicles, where appropriate.

5.64 Language	Cryptosat's Response
(D) The statement must disclose the accuracy, if any, with which orbital parameters will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system will not maintain orbital tolerances, e.g., its propulsion system will not be used for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. All systems must describe the extent of satellite maneuverability, whether or not the space station design includes a propulsion system.	Crypto3 has no propulsion capabilities and will slowly decay from its initial insertion altitude until it re-enters the atmosphere.
(E) The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.	The 18th SDS can contact the Cryptosat satellite operations team 24 hours a day, seven days per week to ensure that Cryptosat can take immediate action to coordinate collision avoidance measures. Cryptosat will update orbital information with the 18th SDS and upon receipt of a space situational conjunction warning, review, and assess collision risk, and take all possible steps to mitigate collision risks, if necessary. Crypto3 is non-propulsive, cannot undertake active avoidance maneuvers, or share ephemeris data.
(ii) Where a space station requests the assignment of a geostationary orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap or touch. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions.	Not applicable.

5.64 Language	Cryptosat's Response
(5) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, exclusive of deployable components. Where the application is for an NGSO space station or system, the statement shall also disclose the following:	Compliant. Crypto3 is at least 10 cm in smallest dimension. Crypto3 is a standard 3U satellite with no deployable mechanism: 30x10x10 cm.
(i) How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive;	Cryptosat will reply on passive monitoring through the space surveillance network.
(ii) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and	Compliant. Satellite has been registered with 18th Space Defense Squadron.
(iii) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.	Cryptosat will provide the 18th SDS updated information on its initial deployment. Crypto3 does not have means to estimate ephemeris and is not capable of maneuvering.
(6) A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.	Not applicable.
(7) A statement detailing the disposal plans for the space station, including the quantity of fuel—if any—that will be reserved for disposal maneuvers. In addition, the following specific provisions apply:	

5.64 Language	Cryptosat's Response
(i) For geostationary orbit space stations, the statement must disclose the altitude selected for a disposal orbit and the calculations that are used in deriving the disposal altitude.	Not applicable.
(ii) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of either through atmospheric re-entry, specifying if direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission.	Crypto3 will decay because of atmospheric drag and the satellite will eventually naturally de-orbit by atmospheric reentry. Crypto3 is expected to re-enter the Earth's atmosphere within 5 years of the end of the satellite mission. There is no fuel onboard the spacecraft.
(iii) For space stations not covered by either paragraph (b)(7)(i) or (ii) of this section, the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.	Not applicable.

5.64 Language	Cryptosat's Response
(iv) For all NGSO space stations under paragraph (b)(7)(ii) or (iii) of this section, the following additional specific provisions apply: (A) The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under paragraph (b)(7)(ii) of this section that will be terminating operations in or passing through low-Earth orbit, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under paragraph (b)(7)(iii) of this section, successful disposal will be assessed on a case-by-case basis.	Compliant.
(B) If planned disposal is by atmospheric re-entry, the statement must also include: (1) A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.	Atmospheric re-entry will be uncontrolled.
(2) An assessment as to whether portions of any individual spacecraft will survive atmospheric re-entry and impact the surface of the Earth with a kinetic energy in excess of 15 joules, and demonstration that the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool is less than 0.0001 (1 in 10,000).	DAS analysis has not yet been performed. No components are expected to survive re-entry based on materials used and the size of the spacecraft.

Iridium L-band Transceivers

The Iridium 9603 modem transceivers onboard Crypto3 satisfy the out-of-band limits specified in Section 25.202(f) of the FCC's rules. The Iridium devices also correct for Doppler frequency shifts due to movement of the satellites. The Iridium specification requires that devices accommodate a Doppler shift of +/- 37.5 kHz through a closed loop signaling protocol with the satellite, *i.e.*, the Doppler is continually tracked and adjusted any time an Iridium device is communicating with a satellite.