Applicant: True Anomaly
File Number: 2110-EX-ST-2022
Correspondence Reference Number: 77411

1. Please provide the station keeping parameters as required by 47 CFR 5.64(b)(4)(i)(D).

While the on-board propulsion system has sufficient delta V to perform mission and maneuvers required to avoid collisions, the spacecraft will not keep orbital tolerances to the apogee, perigee, inclination, and RAAN.

2. Pages 10-11 states the battery monitoring board has protection while on the ground for the two listed cases: battery short and battery over-rate charge. Does this mean these two cases were tested while on the ground and will also function while in orbit, or something else? If there is additional information, please elaborate.

Correct, these two cases were tested while on the ground and will also function while in orbit. All load paths on the space vehicle have over-current protection that is tested on the ground and functional on orbit. The battery charging circuit is designed to keep the maximum charge rate below the battery manufacturer's recommended limit for safety and to extend battery life.

3. On page 11, you indicate the following items under the heading for components which will be passivated at mission end: Payload suite – Star Trackers, NFOV, SWIR, LWIR; S-band Receive/Transmit and Ka-band Transmit; GPS receivers; SADA and SADE; Battery pack. No additional information on the method of passivation for these components is provided. Please provide additional this information as required by 47 CFR 5.64(b)(3).

The power switches to those components will be turned off. They cannot be turned back on without a direct ground command. Since the ground receiver is turned off, no ground command will reach the space vehicle. The propulsion system will use the remaining fuel in the final deorbit burn to the largest extent possible. Less than 1% of the fuel will remain in the system. The valves and pump of the propulsion system need power to operate so after the final burn and power switches are turned off, the propulsion system will not activate again and will be closed off. The final pressure of the propulsion system will be less than 5 PSI. After the deorbit burn all undervoltage protection will be disabled allowing the battery to be discharged completely. The resulting charge setpoint of the battery will be maintained at near 0V to prevent the battery charging. At 22.4V almost no capacity remains in the battery and over time the battery will continue to drift down to 0V which is not dangerous since the battery will not be charged again.

4. On page 13 you indicate you will reserve sufficient propellant to reduce the altitude of the spacecraft to 300 km for purposes of disposal. Please confirm this is 300 km apogee and 300 km perigee.

This is for a perigee of 300 km. We do not plan to perform a burn to circularize the orbit.

5. Please indicate your responses to 47 CFR 5.64(b)(5)(ii), 47 CFR 5.64(b)(5)(iii), 47 CFR 5.64(b)(7)

- (b)(5)(ii) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

True Anomaly has proactively submitted registration with the 18th Space Control Squadron.

- (b)(5)(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.

True Anomaly plans to share pertinent information including initial deployment, recurring ephemeris, and planned maneuvers of each Jackal space vehicle to the 18th Space Defense Squadron.

- (b)(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.

Adequate fuel will be reserved on each vehicle to accommodate a maneuver to lower the spacecraft to ~300 km perigee. The specific quantity of fuel is variable but proportional to the vehicle's current altitude difference from the disposal altitude. Exact values to include fuel mass uncertainty will be tracked once in orbit.

6. Please confirm the presence of hydrazine on the spacecraft, as well as its volatility and how this satisfies requirement 4.4-1 listed on page 11 of the ODAR.

Yes, the spacecraft uses hydrazine. The propulsion system is a low-pressure system where the propellant is stored below 100 PSI. A pump then feeds the thrusters only when firing. The thermal design of the spacecraft prevents the temperature and therefore pressure of the propulsion system from rising to dangerous levels and all components have burst ratings above 800 PSI.

7. Please provide a description of the process you will use for responding to Conjunction Data Messages (CDMs), and more generally for collision avoidance.

True Anomaly will receive CDMs and route them to the spacecraft operations team, which will then confirm and execute a maneuver when necessary. True Anomaly has on-board hardware and software capabilities to ensure timely maneuvering for its own mission and will not have issues conducting additional maneuvers for collision avoidance.

8. Please indicate whether there are any risk thresholds or lead time limits that inform whether and when an action is required, the sequence of events from when a CDM is received to the time a collision avoidance maneuver is executed, etc.

The minimum lead time we would need is 24 hours before an action is required. Once the CDM is received the request will go to the mission manager for review against any planned maneuvers and the mission will be replanned if necessary to satisfy the CDM. New planned maneuvers will be safety checked by ground software, True Anomaly operators, and 18SDS orbital analysts before loading to the spacecraft.

9. Please indicate the targeted level of risk reduction for collision avoidance actions and address whether this targeted level of reduction is routinely achievable by the spacecraft and collision avoidance systems. In support, please provide a timeline of events from time of CDM notification to the time a collision avoidance maneuver decision is made by operators, and the duration of time to fully execute said maneuver.

True Anomaly will follow the operations workflow process defined in the NASA CARA Updated Requirements Architecture. Routine ephemeris and maneuver plans will be delivered to 18 SDS where full catalog screens will be performed. Anytime conjunctions are identified to exceed 1e-4 (1 in 10,000) probability of collision, maneuvers will be planned and executed. The reference timeline from the NASA architecture is defined below.

1) Conjunction Identified (Time of Close Approach (TCA) - 7 days)
2) Risk Characterization (TCA - 5.5 days)
3) Begin Maneuver Analysis (TCA - 3 days)
4) Maneuver Go/No Go (TCA - 1 day)

10. Please include in the description of collision avoidance methods and trajectory screening the method or process for ensuring that third parties are apprised of possible trajectories resulting from any anticipated abort modes, i.e., any maneuvers that would be initiated based on “out of range” spacecraft parameters, relative distances, etc.

True Anomaly will use Monte Carlo analysis to inform the appropriate abort maneuver magnitudes and directions to be loaded on the vehicle. These maneuvers will only be loaded to the spacecraft when performing a proximity operation and will be null otherwise. Anytime abort analysis results in increased probability of collision, the operation will not continue. Ephemeris and maneuver plans will be shared with 18SDS throughout the entirety of this process to ensure any relevant third parties are notified in a timely manner.

11. Please also provide supporting information on the following points: 1. During rendezvous and proximity operations, how often will trajectory information be updated for third parties, and the amount of time between notification and commencement of any trajectory changes. 2. Procedures to be undertaken if the 18th SDS notifies True Anomaly of a potential conjunction during the rendezvous and proximity operation phase of the mission. 3. Any conditions (e.g., maneuver sequences, predicted conjunctions with third parties) under which more frequent observations of data received typically received through telemetry will be undertaken, and, if so, the details of dissemination of any such information or derived data to third parties.

1) The full RPO maneuver plan will be delivered to 18SDS daily, starting 7 days prior to the operation. Notification of significant deviations from the trajectory plan will be made at least one day before commencement of the change.
2) True Anomaly will request increased observation tasking from 18SDS anytime a conjunction is identified. If the conjunction does not offer the luxury of increased tasking and the conjunction presents risk at or above the 1e-4 collision probability threshold, True Anomaly will halt the operation to minimize the number of variables in the safety assessment.
3) True Anomaly will make every effort to consider flight safety the utmost priority. To manage this expectation, increased real-time observations and owner ephemeris made available through telemetry will be shared with 18SDS under any condition that presents a safety concern. Any necessary third-party dissemination for safety reasons is expected to be handled by 18SDS.