**Preliminary Design Review**

The PDR demonstrates that the overall program preliminary design meets all requirements with acceptable risk and within the schedule constraints and establishes the basis for proceeding with detailed design. It shows that the correct design options have been selected, interfaces have been identified, and verification methods have been described. Full baseline schedules, as well as all technical risk have been identified and there are appropriate mitigation plans in place, and metrics are presented.

**I) Summary**

**Team**

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**Launch Vehicle / CSD Interface**

Northrop Grumman Antares

**Overall CubeSat Payload**

The SeaLion satellite is a 3U CubeSat carrying three separate experiments, an impedance probe and VIR-S, from Coast Guard Academy (CGA), and a deployable composite structure (DeCS) from students at Old Dominion University (ODU).

**Mission Statement, Requirements, and Mission Success Criteria**

The SeaLion satellite, operated by teams of students from the Coast Guard Academy and Old Dominion University, aims to verify and validate an impedance probe, a VIR-S, and a deployable composite structure in low-Earth orbit.

The objectives for SeaLion are:

## Primary Mission Objectives (PMOs)

1. Mission SeaLion will establish a UHF communication link with Virginia ground stations.
2. Mission SeaLion shall validate the operation of the IP as a primary payload.
3. Mission SeaLion shall successfully transmit “mission data” defined above to ground stations on the Earth
4. Mission SeaLion shall adhere to CubeSat standards as per CubeSat CDS Rev.13.
5. Mission SeaLion establish an S-band communication link with the MC-3 network of ground stations.

## Secondary Mission Objectives (SMOs)

1. Mission SeaLion shall validate the operation of the VIR-S as a secondary payload.
2. Mission SeaLion shall validate on-orbit the DeCS experiment as secondary payload.

## Tertiary Mission Objectives (TMOs)

1. Mission SeaLion shall validate on-orbit the deployment and functioning of the custom developed UHF antenna system and its deployment.
2. Mission SeaLion shall validate on-orbit a satellite bus for very low Earth orbit CubeSat missions, which includes non-rechargeable batteries as the only power source.
3. Mission SeaLion shall gather DeCS experiment in-orbit performance data by capturing structural behavior through accelerometer and temperature sensor.

## D. Mission Requirements

The satellite must satisfy certain requirements to achieve the above objectives (A1-5, B1-2 and C1-3). The requirements are classified as primary and derived requirements. Each of these is listed below.

## Primary requirements:

1. IP requirements…
2. An attitude determination system (ADS) and inertial measurement unit (IMU) to determine and propagate the angular states of the satellite. The accuracy of the IMU and the ADS shall be better than 5° during the execution of PMO-1 and SMO-2.
3. An onboard transceiver and an antenna system to transmit the “maneuver data” and real time satellite health data, and receive commands from the ground station
4. Telemetry data format(s) for transmission of “maneuver data”
5. A flight computer and peripherals required to co-ordinate ground communication and certain onboard operations
6. Flight software to coordinate ground communication and certain onboard operations
7. A power system primarily designed around non-rechargeable high-energy density batteries to provide power to enable the different operations
8. A satellite bus that shall accommodate the IMU, ADS, transceivers, antenna systems and other support (derived) systems within the CubeSat volume and render the total mass of the satellite to be under 5.88kg. The bus shall adhere to CubeSat specifications.
9. The satellite shall have a flight switch (also called separation switch or deployment switch) for sensing ejection from the P-POD on the –Z side of rail 1 per CubeSat ICD
10. The satellite shall have a “remove before flight” (RBF) switch on the +X face of and is connected in series with the flight switch such that it can be activated (close the circuit) by means of pulling a pin when the satellite is inside the P-POD through the access ports.
11. The satellite shall have two separation springs on the –Z end of two diagonally opposite rails.
12. Ground software for decoding received data and transmitting uplink commands

## Derived requirements

1. A format to store the “mission data“ acquired from sensors, called mission mode telemetry as per the TT&C specification document
2. Six Sun sensors with characteristics per ADS specification document and magnetometer with specifications per the datasheet
3. Analog Devices IMU ADISXXXXX capable of outputting digitized angular rates and pass it on to the OBC via SPI protocol for propagation with specifications per datasheet
4. ADS algorithm (software) with filtering to determine (using Sun vector and magnetic field vector) and/or propagate (using angular velocity vector) the satellite attitude with an accuracy better than 5°
5. A/D converter(s) for sampling the Sun sensor and magnetometer data
6. Transceiver (COTS) radio transceiver controlled by the flight computer to
   1. Transmit via a dipole antenna system per the TT&C specifications document, real time data and stored operation data in formats (listed below) referred to as “telemetry”
      1. Safe hold mode telemetry format
      2. Mission Mode 1 telemetry format
      3. Mission Mode 2 telemetry format
   2. Receive encoded uplink data according to the uplink data format and transfer it to the flight computer for parsing per the TT&C specifications document
7. Dipole antenna sets (stowed during launch) for transmitting from Transceiver and receiving data from ground station per TT&C specifications document
8. Deployment and stowage mechanisms for antennae
9. Flight computer hardware and software per the TT&C specifications document to perform the following tasks
10. Execute a wait period of 45 minutes before deployment of antennae and transmission via the transceiver.
11. Collecting satellite health data and assembling telemetry per 11.a (above)
12. Storing telemetry data per the TT&C specifications document
13. Commanding the Transceiver for sending telemetry data and receiving uplink data
14. Digitizing the analog Sun sensors (6) and magnetometer (3) signals
15. Commanding the EPS board for acquiring power and temperature (health) data via I2C and power resets
16. Deploying communications antennas by enabling load switches
17. Mission profile and sequence of operations
18. Satellite bus design per the satellite bus specifications document to support and accommodate
19. IMU (1), magnetometers (2) and Sun sensors (6)
20. Transceiver (2)
21. Tx and Rx Antennae with deployment system
22. Flight computer board (1) with RBF switch (1)
23. EPS with batteries
24. Deployment switch (1) and Deployment springs (2)
25. Electrical and signal routing
26. Satellite integrated operations supporting primary objectives

Table 1. Verification Matrix for Mission SeaLion

(**T**-test and measurement, **A**-analysis and simulation, **O**-observation and inspection, **R**-reference and datasheet)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Requirement** | **Verification Description** | **T** | **A** | **O** | **R** |
|  | A2 | ADS accuracy | X | X |  |  |
|  | A9 | Satellite total mass | X | X |  |  |
|  | A9 | Satellite volume and dimension | X |  |  |  |
|  | A10 | Flight switch (location and functionality test) | X |  | X |  |
|  | A11 | RBF switch (accessibility and functionality test) | X |  | X |  |
|  | A12 | Location of separation springs |  |  | X |  |
|  | A13 | Ground station functionality | X |  |  |  |
|  | B4 | Sun sensor functionality and characteristics | X |  |  |  |
|  | B4 | Magnetometer characteristics | X |  |  | X |
|  | B5 | IMU characteristics | X |  |  | X |
|  | B4 & B5 | ADS hardware environmental | X |  |  |  |
|  | B6 | ADS algorithm accuracy |  | X |  |  |
|  | B6 | IMU Propagation accuracy |  | X |  |  |
|  | B7 | A/D converter functionality | X |  |  |  |
|  | B11a & B11b | Transceiver functionality | X |  |  |  |
|  | B11 | Transceiver environmental | X |  |  |  |
|  | B12 | Antenna radiation pattern and functionality | X |  |  |  |
|  | B13 | Antenna deployment | X |  |  |  |
|  | B14a | Satellite sensor data collection and telemetry string assembly | X |  |  |  |
|  | B14b | Commanding Transceiver to transmit stored/realtime data | X |  |  |  |
|  | B14b | Receiving uplink data from Transceiver, parsing and taking appropriate action | X |  |  |  |
|  | B14c | A/D sampling and acquisition | X |  |  |  |
|  | B14d | Communicating with EPS | X |  |  |  |
|  | B14f | Commanding antenna deployment | X |  |  |  |
|  | B14 | GomSpace Nanomind A3200 environmental | X |  |  |  |
|  | B15 | Mission operations software cycles (Day in the life test) | X | X |  |  |
|  | B16 | EPS functionality test | X |  |  |  |
|  | B16 | EPS environmental | X |  |  |  |
|  | B18 | Satellite bus construction | X | X |  |  |
|  | B19 | Satellite bus environmental | X |  |  |  |
|  | B19 | Satellite functionality and operations | X | X | X |  |

**II) Science Value**

* Describe Science Payload Objectives
* State the payload success criteria
* Describe the experimental logic, approach, and method of investigation
* Describe test and measurement, variables and controls
* Show relevance of expected data, accuracy/error analysis
* Describe the Preliminary Experiment process procedures
* Present High Level design of experiment(s)

**III) Payload /Mission Design and Performance Predictions**

* State mission performance criteria
* Show flight profile simulations, altitude predictions with simulated vehicle data
* Mass, Power, Volume, Data and Telemetry estimates and Margins
* TT&C approach
* Review the design at a system level, going through each system’s functional requirements (Includes sketches of options, selection rationale, selected concept and characteristics)
* Describe the subsystems that are required to accomplish the overall mission:
* Describe the performance characteristics for the system and subsystems and determine the evaluation and verification metrics.
* Describe the verification plan and its status.
* Define the risks and the plans for reducing the risks through analysis or testing for each system. A risk plot that clearly portrays the risk mitigation schedule is highly encouraged. Take all factors that might affect the project including risks associated with testing, delivery of parts, adequate personnel, school holidays, budget costs, etc. Demonstrate an understanding of all components needed to complete the project and how risks/delays impact the project
* Demonstrate planning of manufacturing, verification, integration, and operations. (Include component testing, functional testing, or static testing)
* Confidence and maturity of design
* Include a dimensional drawing of entire Cube Sat Payload

**IV) Payload Integration**

* Describe integration plan with an understanding that the payload must be co-developed with the CSD and meet all Launch Vehicle interface requirements
* Develop an outline of final assembly, integration, and launch/operations procedures

**V) Safety and Environment**

* Provide a Preliminary analysis of the failure modes of the proposed design, payload integration and launch operations, including proposed and completed mitigations.
* Provide a listing of personnel hazards, and data demonstrating that Safety Hazards have been researched and that hazard mitigations have been addressed and mitigated.
* Discuss any environmental concerns.

**VI) Activity Plan**

* Payload development, integration, functional and environmental test, and operations schedule
* Outreach summary

**VII) Conclusion**