SeaLion Mission Architecture

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Stakeholder Needs

The SeaLion Mission Architecture is guided by a series of stakeholder needs, listed below.

1.1: Primary Mission Objective A1

> The SeaLion mission shall establish UHF communication link with Virginia ground station

1.2: Primary Mission Objective A2

> The SeaLion mission shall establish S-Band communication link with MC3 ground station

1.3: Primary Mission Objective A3

> The SeaLion mission shall successfully transmit “mission data” defined above to ground stations on the Earth.

1.4: Primary Mission Objective A4

> The SeaLion mission shall adhere to CubeSat standards as per CDS Rev. 13

Reference:

- CubeSat Design Specification Rev. 13

1.5: Primary Mission Objective A5

> The SeaLion mission shall validate the operation of the Impedance Probe (IP) as a primary payload in-orbit.

2.1: Secondary Mission Objective B1

> The SeaLion mission shall provide a means to validate a Multi-spectral Sensor (Ms-S) in-orbit

2.2: Secondary Mission Objective B2

The SeaLion mission shall provide a means to validate a deployable composite structure (DeCS) in-orbit

3.1: Tertiary Mission Objective C1

The SeaLion mission shall qualify on-orbit the deployment and functioning of the newly developed UHF antenna system and its deployment.

3.2: Tertiary Mission Objective C2

The SeaLion mission shall qualify a CubeSat bus architecture for very-low Earth orbit (VLEO)

3.3: Tertiary Mission Objective C3

The SeaLion shall verify DeCS in-orbit behavior performance.

User Stories

The SeaLion Mission Architecture's stakeholder needs are then used to identify a series of user stories which then lead to design decisions captured in data structure and activity definitions.

1: Ping Satellite

As a **Ground Station Operator** I want to **Ping satellite** so that I can **Establish communication link with satellite**.

Example:

Ping the satellite in order to establish UHF communication link with Virginia ground station

Derived From:

- Primary Mission Objective A1

2: View Satellite Health Data Packet

> As a **Ground Station Operator** I want to **view satellite health data packet** so that I can **validate that satellite is operating nominally**.

Example:

View satellite health data packet to verify or validate AODS sensor & GPS data is within nominal range and/or corresponds to expected orbit profile

2.1: Listen for Satellite Beacon

> As a **Ground Station Operator** I want to **Open ground station beacon monitor** so that I can **View satellite health data packet**.

Example:

Open ground station beacon monitor to listen for satellite health data packet downlink

Derived From:

- View Satellite Health Data Packet

3: Update Beacon Rate

> As a **Ground Station Operator** I want to **Update Beacon Rate** so that I can **Conserve power budget**.

Example:

Update beacon rate to transmit every 30 minutes to conserve power

4: Request Telemetry Data

> As a **Ground Station Operator** I want to **Request satellite telemetry data packets** so that I can **Locally verify/validate onboard AODS computations**.

Example:

Request satellite telemetry packets for local verification/validation of onboard AODS computations

4.1: Request Satellite Health Data

> As a **Ground Station Operator** I want to **request satellite health data packet** so that I can **verify/validate AODS sensors & GPS data are within nominal parameters**.

Example:

Request satellite health data packet to verify or validate AODS sensors and GPS data correspond to expected attitude and/or orbit profile based on pre-computed attitude or orbit propagation model

Derived From:

- Request Telemetry Data

4.2: Request Satellite AODS Sensor Data

> As a **Ground Station Operator** I want to **request satellite AODS sensor data** so that I can **verify AODS sensor data yields nominal parameters**.

Example:

Request satellite AODS sensor data for verifying AODS sensor data corresponds with a known magnetic field, light source, and/or change in orientation w.r.t. satellites body frame of reference

Derived From:

- Request Telemetry Data

5: Payload Scheduler

> As a **Ground Station Operator** I want to **schedule data collection to occur at specfied orbital position** so that I can **allow satellite mission modes to autonomously record data**.

Example:

5.1: Deployable Composite Structure (DeCS) Payload Scheduler

> As a **Ground Station Operator** I want to **schedule data collection to occur at specfied orbital position** so that I can **allow satellite mission modes to autonomously record data**.

Example:

Schedule data recording at specfic orbital location to another orbital location for Deployable Composite Structure Payload

Derived From:

- Secondary Mission Objective B2
- Tertiary Mission Objective C3

5.2: Impedance Probe Payload Scheduler

> As a **Ground Station Operator** I want to **Schedule data recording at specfic orbital location** so that I can **Recording data for future transmission**.

Example:

Schedule data recording at specfic orbital location to another orbital location for impedance probe payload

Derived From:

- Primary Mission Objective A5

5.3: Multi-spectral Sensor Scheduler

> As a **Ground Station Operator** I want to **Schedule data recording at specfic orbital location** so that I can **Recording data for future transmission**.

Example:

Schedule data recording at specfic orbital location to another orbital location for Multi-spectral Sensor payload

Derived From:

- Secondary Mission Objective B1

5.4: Downlink Payload Data TLE

> As a **Ground Station Operator** I want to **Transmit TLE schedulered satellite recorded data to ground station** so that I can **Vacant on-board memory for more data**.

Example:

Start downlink TLE schedulered payload data once the satellite is in line of sight

Derived From:

- Primary Mission Objective A3

6: Payload Scheduler

> As a **Ground Station Operator** I want to **Schedule data recording at specfic time interval** so that I can **Recording data for future transmission**.

Example:

6.1: Deployable Composite Structure (DeCS) Payload Scheduler

> As a **Ground Station Operator** I want to **Schedule data recording at specfic time interval (or orbital location)** so that I can **Recording data for future transmission**.

Example:

Schedule data recording at specfic time interval for Deployable Composite Structure Payload

Derived From:

- Secondary Mission Objective B2
- Tertiary Mission Objective C3

6.2: Impedance Probe Payload Scheduler

> As a **Ground Station Operator** I want to **Schedule data recording at specfic time interval** so that I can **Recording data for future transmission**.

Example:

Schedule data recording at specfic time interval for Impedance Probe Payload

Derived From:

- Primary Mission Objective A5

6.3: Multi-spectral Sensor Payload Scheduler

> As a **Ground Station Operator** I want to **Schedule data recording at specfic time interval** so that I can **Recording data for future transmission**.

Example:

Schedule data recording at specfic time interval for Multi-spectral Sensor Payload

Derived From:

- Secondary Mission Objective B1

6.4: Downlink Payload Data Time Interval

> As a **Ground Station Operator** I want to **Transmit time interval schedulered satellite recorded data to ground station** so that I can **Vacant on-board memory for more data**.

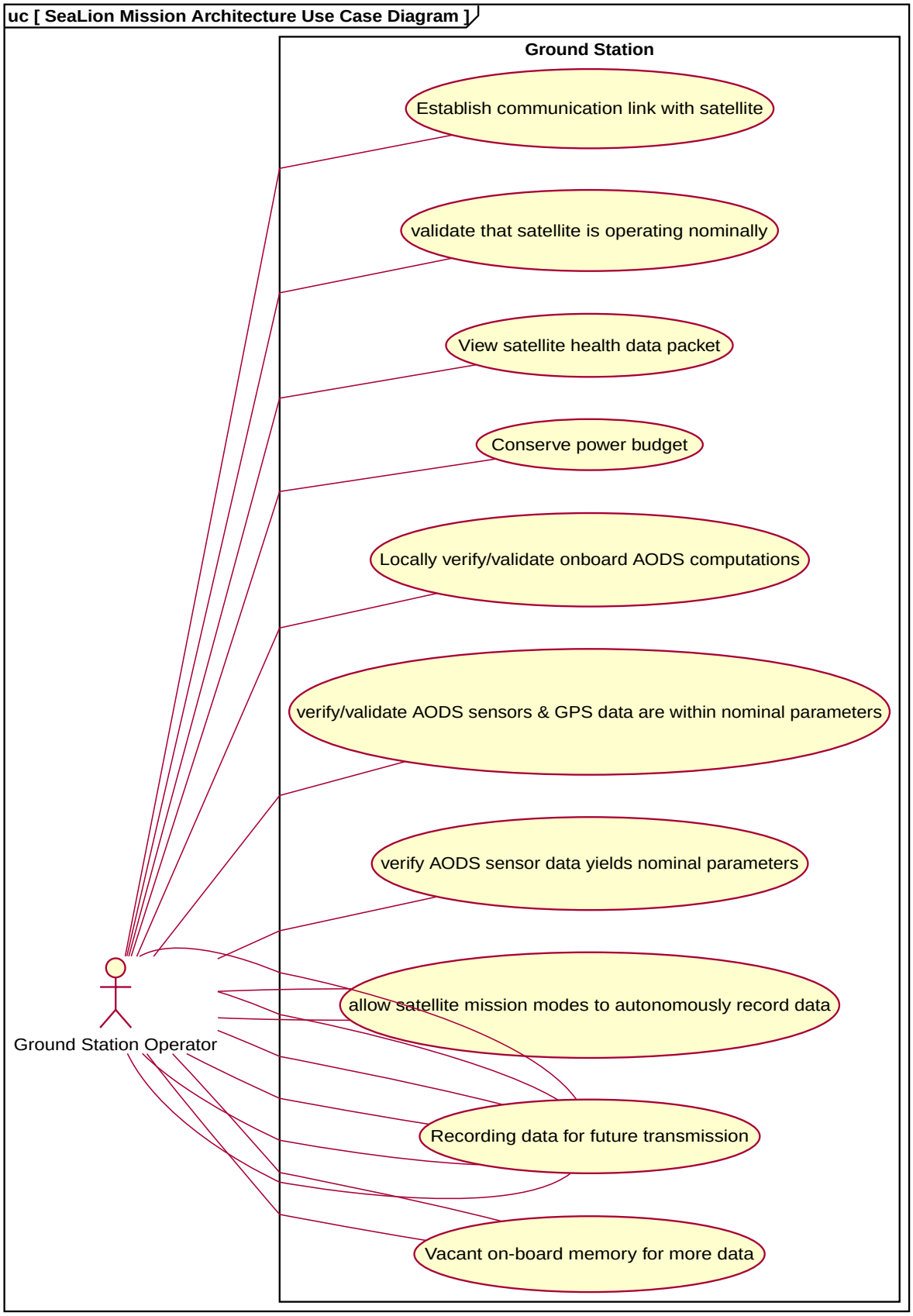
Example:

Start downlink time interval schedulered payload Data once the satellite is in line of sight

Derived From:

- Primary Mission Objective A3

User stories as Use Case Diagram


uc [SeaLion Mission Architecture Use Case Diagram]
Ground Station
Establish communication link with satellite
validate that satellite is operating nominally
View satellite health data packet
Conserve power budget
Locally verify/validate onboard AODS computations
verify/validate AODS sensors & GPS data are within nominal parameters
verify AODS sensor data yields nominal parameters
allow satellite mission modes to autonomously record data
Recording data for future transmission
Vacant on-board memory for more data
Ground Station Operator

Data Structures

This section covers each data structure type in the **SeaLion Mission Architecture**.

Satellite Health Data Packet

Purpose: Data structure for satellite health data packet used for beacon telemetry

Satellite Health Data Packet Template

```
call_sign: {{call_sign}}
battery_health: {{battery_health}}
mode: {{mode}}
tle_data: {{tle_data}}
```

Field	Type	Item Type	Description	Source
call_sign	string		Identifying call sign for the Sealion mission.	
battery_health	float		Percent value indicating the remaining charge of the batteries.	
mode	integer		Integer value indicating current mission mode. 0 = Safe, 1 = mission mode 1, 2 = mission mode 2, 3 = mission mode 3.	
tle_data	3-DataStructures/4-TLE.yaml		TLE data from orbit propogator at time of beacon.	

Table 1. Satellite Health Data Packet Specification

Derived From:

- View Satellite Health Data Packet
- Request Satellite Health Data

Satellite AODS IC Data

Purpose: Data structure for satellite AODS initial conditions data packet used for attitude determination and orbit propagation

Satellite AODS IC Data Template

```
imu_gyro_x: {{imu_gyro_x}}
imu_gyro_y: {{imu_gyro_y}}
imu_gyro_z: {{imu_gyro_z}}
imu_magnetometer_x: {{imu_magnetometer_x}}
imu_magnetometer_y: {{imu_magnetometer_y}}
imu_magnetometer_z: {{imu_magnetometer_z}}
sun_sensor_pitch_pos: {{sun_sensor_pitch_pos}}
sun_sensor_pitch_neg: {{sun_sensor_pitch_neg}}
sun_sensor_yaw_pos: {{sun_sensor_yaw_pos}}
sun_sensor_yaw_neg: {{sun_sensor_yaw_neg}}
sun_sensor_roll_pos: {{sun_sensor_roll_pos}}
sun_sensor_roll_neg: {{sun_sensor_roll_neg}}
time_stamp: {{time_stamp}}
altitude_data_GPS: {{altitude_data}}
lattitude_GPS: {{lattitude}}
longitude_GPS: {{longitude}}
```

Field	Type	Item Type	Description	Source
imu_gyro_x	float		The angular rate of the body with to respective to the x-axis in the IMU's reference frame.	
imu_gyro_y	float		The angular rate of the body with to respective to the y-axis in the IMU's reference frame.	
imu_gyro_z	float		The angular rate of the body with to respective to the z-axis in the IMU's reference frame.	
imu_magnetometer_x	float		The magnetic field strength with respective to the x-axis in the IMU's reference frame.	
imu_magnetometer_y	float		The magnetic field strength with respective to the y-axis in the IMU's reference frame.	
imu_magnetometer_z	float		The magnetic field strength with respective to the z-axis in the IMU's reference frame.	
sun_sensor_pitch_pos	float		Sun sensor measurement with respect to positive pitch angle.	• []

Field	Type	Item Type	Description	Source
sun_sensor_pitch_neg	float		Sun sensor measurement with respect to negative pitch angle.	• []
sun_sensor_yaw_pos	float		Sun sensor measurement with respect to positive yaw angle.	• []
sun_sensor_yaw_neg	float		Sun sensor measurement with respect to negative yaw angle.	• []
sun_sensor_roll_pos	float		Sun sensor measurement with respect to positive roll angle.	• []
sun_sensor_roll_neg	float		Sun sensor measurement with respect to negative roll angle.	• []
time_stamp	string		Time stamp of the last transmission.	
altitude_data_GPS	float		The altitude data of the satellite from GPS.	
lattitude_GPS	float		Lattitude coordinate of the satellite from GPS.	
longitude_GPS	float		Longitude coordinate of the satellite from GPS.	

Table 2. Satellite AODS IC Data Specification

Derived From:

Satellite AODS Sensor Data

Purpose: Data structure for satellite AODS sensor data used for attitude determination or incremental orbit propogation

Satellite AODS Sensor Data Template

```
imu_gyro_x: {{imu_gyro_x}}
imu_gyro_y: {{imu_gyro_y}}
imu_gyro_z: {{imu_gyro_z}}
imu_magnetometer_x: {{imu_magnetometer_x}}
imu_magnetometer_y: {{imu_magnetometer_y}}
imu_magnetometer_z: {{imu_magnetometer_z}}
sun_sensor_pitch_pos: {{sun_sensor_pitch_pos}}
sun_sensor_pitch_neg: {{sun_sensor_pitch_neg}}
sun_sensor_yaw_pos: {{sun_sensor_yaw_pos}}
sun_sensor_yaw_neg: {{sun_sensor_yaw_neg}}
sun_sensor_roll_pos: {{sun_sensor_roll_pos}}
sun_sensor_roll_neg: {{sun_sensor_roll_neg}}
time_stamp: {{time_stamp}}
```

Field	Type	Item Type	Description	Source
imu_gyro_x	float		The angular rate of the body with to respective to the x-axis in the IMU’s reference frame.	
imu_gyro_y	float		The angular rate of the body with to respective to the y-axis in the IMU’s reference frame.	
imu_gyro_z	float		The angular rate of the body with to respective to the z-axis in the IMU’s reference frame.	
imu_magnetometer_x	float		The magnetic field strength with respective to the x-axis in the IMU’s reference frame.	
imu_magnetometer_y	float		The magnetic field strength with respective to the y-axis in the IMU’s reference frame.	
imu_magnetometer_z	float		The magnetic field strength with respective to the z-axis in the IMU’s reference frame.	
sun_sensor_pitch_pos	float		Sun sensor measurement with respect to positive pitch angle.	• []
sun_sensor_pitch_neg	float		Sun sensor measurement with respect to negative pitch angle.	• []

Field	Type	Item Type	Description	Source
sun_sensor_yaw_pos	float		Sun sensor measurement with respect to positive yaw angle.	• []
sun_sensor_yaw_neg	float		Sun sensor measurement with respect to negative yaw angle.	• []
sun_sensor_roll_pos	float		Sun sensor measurement with respect to positive roll angle.	• []
sun_sensor_roll_neg	float		Sun sensor measurement with respect to negative roll angle.	• []
time_stamp	string		Time stamp of the last transmission.	

Table 3. Satellite AODS Sensor Data Specification

Derived From:

- Request Satellite AODS Sensor Data

TLE

Purpose: Data structure for the TLE data

TLE Template

```
tle_line_1: {{tle_line_1}}
tle_line_2: {{tle_line_2}}
```

Field	Type	Item Type	Description	Source
tle_line_1	3-DataStructures/5-TLELine1.yaml		Data for TLE line 1	

Field	Type	Item Type	Description	Source
tle_line_2	3-DataStructures/6-TLELine2.yaml		Data for TLE line 2	

Table 4. TLE Specification

Derived From:

- Two-Line Element Data

TLE Line 1

Purpose: Data structure for the first line of the TLE data

TLE Line 1 Template

```
line_number: {{line_number}}
satellite_number: {{satellite_number}}
classification: {{classification}}
international_designator_1: {{international_designator_1}}
international_designator_2: {{international_designator_2}}
international_designator_3: {{international_designator_3}}
epoch_year: {{epoch_year}}
epoch: {{epoch}}
first_dt: {{first_dt}}
second_dt: {{second_dt}}
bstar: {{bstar}}
eph_type: {{eph_type}}
element_number: {{element_number}}
checksum: {{checksum}}
```

Field	Type	Item Type	Description	Source
line_number	string		Line number of element data (Column 01)	
satellite_number	string		Satellite number (Column 03-07)	
classification	string		Classification of satellite (Column 08)	

Field	Type	Item Type	Description	Source
international_designator_1	string		International designator 1 (last two digits of launch year) (Column 10-11)	
international_designator_2	string		International designator 2 (launch number of the year) (Column 12-14)	
international_designator_3	string		International designator 3 (piece of the launch) (Column 15-17)	
epoch_year	string		Epoch year (last two digits of year) (Column 19-20)	
epoch	string		Epoch (day of the year and fractional portion of the day) (Column 21-32)	
first_dt	string		First time derivative of the mean motion (Column 34-43)	
second_dt	string		Second time derivative of the mean motion (leading decimal point assumed) (Column 45-52)	
bstar	string		BSTAR drag term (leading decimal point assumed) (Column 54-61)	
eph_type	string		Ephemeris type (Column 63)	
element_number	string		Element number (Column 65-68)	
checksum	string		Checksum (modulo 10) (letters, blanks, periods, plus signs = 0; minus signs = 1) (Column 69)	

Table 5. TLE Line 1 Specification

Derived From:

- Two-Line Element Data

TLE Line 2

Purpose: Data structure for the second line of the TLE data

TLE Line 2 Template

```
line_number: {{line_number}}
satellite_number: {{satellite_number}}
inclination: {{inclination}}
raan: {{raan}}
ecc: {{ecc}}
perigee: {{perigee}}
mean_anomaly: {{mean_anomaly}}
mean_motion: {{mean_motion}}
rev_epoch: {{rev_epoch}}
checksum: {{checksum}}
```

Field	Type	Item Type	Description	Source
line_number	string		Line number of element data (Column 01)	
satellite_number	string		Satellite number (Column 03-07)	
inclination	string		Inclination (degrees) (Column 09-16)	
raan	string		Right ascension of the ascending node (degrees) (Column 18-25)	
ecc	string		Eccentricity (leading decimal point assumed) (Column 27-33)	
perigee	string		Argument of perigee (degrees) (Column 35-42)	
mean_anomaly	string		Mean anomaly (degrees) (Column 44-51)	
mean_motion	string		Mean motion (revs per day) (Column 53-63)	
rev_epoch	string		Revolution number at epoch (revs) (Column 64-68)	
checksum	string		Checksum (modulo 10) (letters, blanks, periods, plus signs = 0; minus signs = 1) (Column 69)	

Table 6. TLE Line 2 Specification

Derived From:

- Two-Line Element Data

Finite State Machine