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 Beacon Data

> As a **Ground Station Operator** I want to **view satellite beacon data (alternating between health & mission data), received via UHF** so that I can **verify that satellite is operating nominally**.

Example:

View satellite beacon data (health or mission data) to verify that TLE's correspond with expected orbit profile and/or to validate that a mission mode was successful

Derived From:

- Primary Mission Objective A1
- Primary Mission Objective A3
- Primary Mission Objective A5
- Secondary Mission Objective B1
- Secondary Mission Objective B2
- Tertiary Mission Objective C1
- Tertiary Mission Objective C2
- Tertiary Mission Objective C3

3: Send Request to Set Interrupt Timer

> As a **Ground Station Operator** I want to **send a request to set count value at which interrupt timers (i.e., beacon, GPS ping, or orbit propagator) are triggered** so that I can **finetune parameters for attitude or orbit analysis or to conserve power**.

Example:

Update beacon rate to transmit every 30 minutes to conserve power

4: Request Telemetry or EventLog Data

> As a **Ground Station Operator** I want to **Request satellite telemetry or eventlog data** so that I can **verify/validate health status or mission data**.

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 TLE data corresponding to expected orbit profile based on pre-computed orbit propagation model

Derived From:

- Request Telemetry or EventLog Data

4.1.1: Request Satellite Health Data via S-Band Radio

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

Example:

Request satellite health data packet via S-band radio to verify or validate TLE data corresponding to expected orbit profile based on pre-computed orbit propagation model

Derived From:

- Request Telemetry or EventLog Data
- Primary Mission Objective A2

4.2: Request Satellite Mission Data

> As a **Ground Station Operator** I want to **request satellite mission data** so that I can **validate in-orbit AODS and/or payload performance**.

Example:

Request satellite mission data to verify that TLE’s & AODS sensor data correspond with expected orbit profile and/or validate that a mission mode was successful

Derived From:

- Request Telemetry or EventLog Data
- Primary Mission Objective A1
- Primary Mission Objective A3
- Primary Mission Objective A5
- Secondary Mission Objective B1
- Secondary Mission Objective B2
- Tertiary Mission Objective C1
- Tertiary Mission Objective C2
- Tertiary Mission Objective C3

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: Send Request to Set Mission Mode Duration

> As a **Ground Station Operator** I want to **send a request to set mission mode duration** so that I can **manage time spent per mission mode**.

Example:

send a request to set Mission Mode 1 duration to 25 minutes

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**.

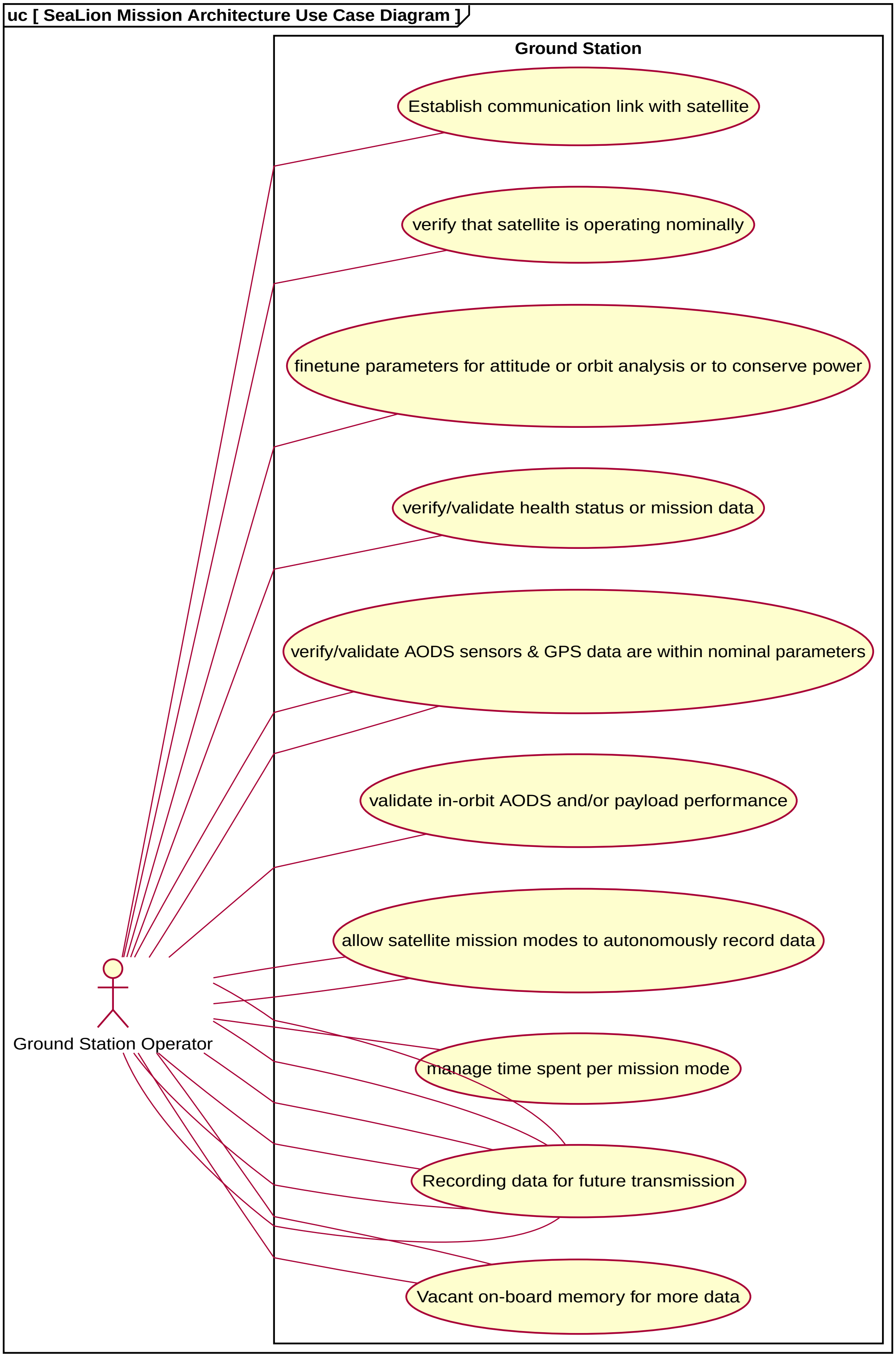
Example:

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
verify that satellite is operating nominally
finetune parameters for attitude or orbit analysis or to conserve power
verify/validate health status or mission data
verify/validate AODS sensors & GPS data are within nominal parameters
validate in-orbit AODS and/or payload performance
allow satellite mission modes to autonomously record data
manage time spent per mission mode
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}}
temperature_battery: {{temperature_battery}}
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.	
temperature_battery	float		The temperature of the battery. Units in Kelvin.	
mode	integer		Integer value indicating current mission mode. 0 = Safe, 1 = mission mode 1, 2 = mission mode 2, 3 = mission mode 3.	
tle_data	TLE		TLE data from orbit propogator at time of beacon.	

Table 1. Satellite Health Data Packet Specification

Derived From:

- View Satellite Beacon Data
- Request Satellite Health Data

Satellite GPS Data

Purpose: Data structure for GPS data used for orbit propagation

Satellite GPS Data Template

```
time_stamp: {{time_stamp}}
altitude_data_GPS: {{altitude_data}}
lattitude_GPS: {{lattitude}}
longitude_GPS: {{longitude}}
```

Field	Type	Item Type	Description	Source
time_stamp	string		Time stamp when GPS data was acquired.	
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 GPS Data Specification

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.	• []
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:

TLE

Purpose: Data structure for the TLE data computed from GPS data or orbit propagator

TLE Template

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

Field	Type	Item Type	Description	Source
tle_line_1	TLELine1		Data for TLE line 1	
tle_line_2	TLELine2		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)	
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

Mission Data

Purpose: Defines EVR (event) elements to be recorded to the eventLog during a mission mode

Mission Data Template

```
entry_tle: {{entry_tle}}
obc_sensors: {{obc_sensors}}
mission_data: {{mission_data}}
exit_tle: {{exit_tle}}
```

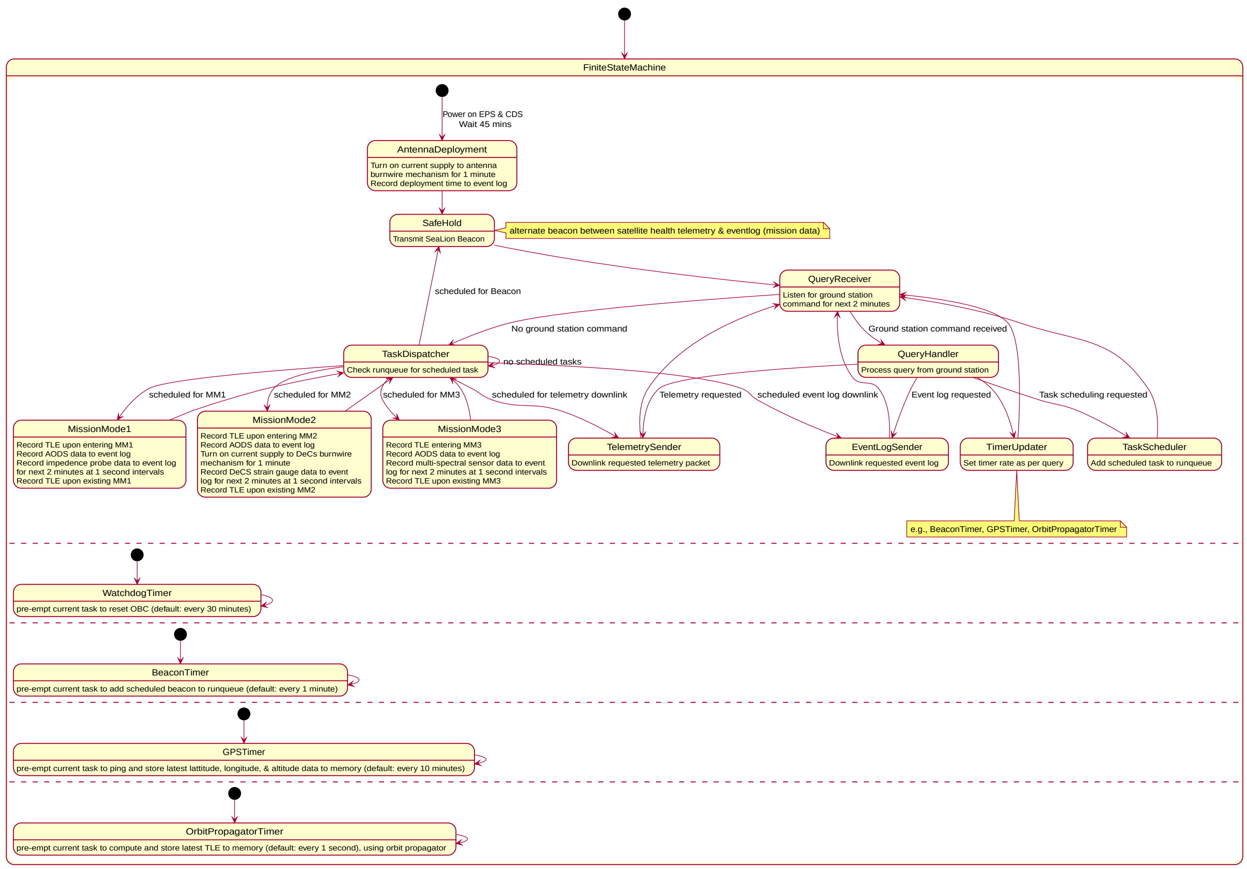
Field	Type	Item Type	Description	Source
entry_tle	TLE		TLE at time of beginning of mission mode	
obc_sensors	AODSSensorData		AODS Sensor data	
mission_data	string		Data recorded during mission mode	
exit_tle	TLE		TLE at time of end of mission mode	

Table 7. Mission Data Specification

Derived From:

- View Satellite Beacon Data
- Request Satellite Mission Data

Finite State Machine


FiniteStateMachine
Power on EPS & CDS
Wait 45 mins
AntennaDeployment
Turn on current supply to antenna
burnwire mechanism for 1 minute
Record deployment time to event log
SafeHold
Transmit SeaLion Beacon
alternate beacon between satellite health telemetry & eventlog (mission data)
QueryReceiver
Listen for ground station
command for next 2 minutes
scheduled for Beacon
No ground station command
Ground station command received
TaskDispatcher
Check runqueue for scheduled task
no scheduled tasks
QueryHandler
Process query from ground station
scheduled for MM1
scheduled for MM2
scheduled for MM3
scheduled for telemetry downlink
Telemetry requested
scheduled event log downlink
Event log requested
Task scheduling requested
MissionMode1
Record TLE upon entering MM1
Record AODS data to event log
Record impedence probe data to event log
for next 2 minutes at 1 second intervals
Record TLE upon existing MM1
MissionMode2
Record TLE upon entering MM2
Record AODS data to event log
Turn on current supply to DeCs burnwire
mechanism for 1 minute
Record DeCS strain gauge data to event
log for next 2 minutes at 1 second intervals
Record TLE upon existing MM2
MissionMode3
Record TLE entering MM3
Record AODS data to event log
Record multi-spectral sensor data to event
log for next 2 minutes at 1 second intervals
Record TLE upon existing MM3
TelemetrySender
Downlink requested telemetry packet
EventLogSender
Downlink requested event log
TimerUpdater
Set timer rate as per query
TaskScheduler
Add scheduled task to runqueue
e.g., BeaconTimer, GPSTimer, OrbitPropagatorTimer
WatchdogTimer
pre-empt current task to reset OBC (default: every 30 minutes)
BeaconTimer
pre-empt current task to add scheduled beacon to runqueue (default: every 1 minute)
GPSTimer
pre-empt current task to ping and store latest lattitude, longitude, & altitude data to memory (default: every 10 minutes)
OrbitPropagatorTimer
pre-empt current task to compute and store latest TLE to memory (default: every 1 second), using orbit propagator