Shannon

ORBITAL DEBRIS ASSESSMENT REPORT

Lynk Global, INC.
510 N. WASHINGTON ST, SUITE 200, FALLS CHURCH, VA 22046

PREPARED BY Thatcher Chamberlin **Systems Engineer**		NUMBER	
APPROVALS		**TYPE** Analysis Procedure	
Approved By: Tyghe Speidel **VP, Technology & Strategy**		**DATE** February 3, 2021 **Final release date**	
Concurrence:		**SUPERSEDES SPEC DATED** **NA**	
		REV **01**	

TITLE: Orbital Debris Assessment Report (ODAR) / End of Mission Plan (EOMP)

TABLE OF CONTENTS

Requirement	Launch Vehicle				Spacecraft			Comments
	Compliant	Not Compliant	Incomplete	Standard Non-Compliant	Compliant	Not Complaint	Incomplete	
4.3-1.a	N/A				X			No debris released in LEO
4.3-1.b					X			No debris released in LEO
4.3-2					X			No debris released in GEO
4.4-1					X			Less than 0.001 probability
4.4-2					X			Designed to passivate electrical power system and reaction wheels
4.4-3					X			No planned breakups
4.4-4					X			No planned breakups
4.5-1					X			Probability 0.00000 (requirement < 0.001)
4.5-2					X			Probability 0.00000 (requirement < 0.01)
4.6-1(a)					X			Predicted orbital lifetime <19.8 yrs
4.6-1(b)					X			N/A – using atmospheric entry
4.6-1(c)					X			N/A – using atmospheric entry
4.6-2					X			N/A – Not GEO
4.6-3					X			N/A – Not between LEO and GEO
4.6-4					X			Expected probability < 0.001
4.7-1					X			No pieces survive reentry
4.8-1					X			No tethers used

Shannon is currently manifested to launch in June 2021 on the SpaceX SRSX-5 Rideshare mission to SSO. Compliance with requirements levied by NASA-STD 9719.14A on the launch vehicle are not applicable to this document and remain the launch provider's responsibility.

Lynk contracted with Spaceflight Services, located in Auburn, Washington, to provide manifesting and launch vehicle integration services for the *Shannon* satellite.

Compliance NASA-STD 9719.14A requirements on the launch vehicle are not applicable to this document and remain the launch provider's responsibility.

1 PROGRAM MANAGEMENT AND MISSION OVERVIEW

1.1 Program Management

Parameter	Value
Mission Directorate	N/A
Program Executive	Tyghe Speidel (VP, Technology)
Program/Project Manager	Tyghe Speidel (VP, Technology)

Table 1 - Summary of Program Management Personnel

1.2 Mission Overview

1.2.1 Mission Design and Development Milestones

The project milestones for the *Shannon* satellite align with the launch date of the mission. The delivery milestone for the spacecraft is approximately one to two months prior to its projected launch date.

1.2.2 Mission Overview

The goal of the *Shannon* is to provide two-way data communications to/from standard cellular/mobile devices in remote locations the Earth.

Parameter	*Shannon* Satellite
Launch vehicle and launch site	Space X SSO Falcon 9 Rideshare
Proposed launch date	June 2021
Mission duration	The operational lifetime of the hardware and electronics for this satellite is designed to 3-5 years following deployment from the launch vehicle. The orbital lifetime for the satellite is expected to be less than 12 years, depending on the vehicle's orbit, its orientation, and the solar influence of the Earth's atmosphere, as described in Section 6.
Launch and deployment profile	This Lynk satellite will decay naturally for debris mitigation and will re-enter within 25 years after completion of mission.

Table 2: Summary of Mission Parameters

2 SPACECRAFT DESCRIPTION

2.1 Physical Description of Spacecraft

The *Shannon* spacecraft has been designed to support a 3 to 5 year mission in sun-synchronous low-Earth orbit. The spacecraft is flat box with dimensions of 1 m x 1 m x 0.15 m and with a mass of roughly 40 kg.

The Lynk spacecraft design uses subsystem modules primarily built from printed circuit boards (PCB) or miniature enclosures mounted to the open frame primary structure. The open structure permits the vehicle to be built incrementally with open access for securing interconnects. The subsystems are placed within the vehicle to optimize mass properties, radiation protection, thermal heat rejection, power handling, vehicle orientation, and cabling length. The body mounted side panels and attach directly to the primary structure and are used for thermal management and can be easily removed to get access to the interior of the vehicle. The vehicle is primarily constructed out of aluminum and PCB materials.

Parameter	Value
Total satellite mass at launch, including all propellants and fluids	~40 kg
Dry Mass of satellite at launch, excluding solid rocket motor propellants	~40 kg
Form Factor	Flat Square Panel
Center of Mass	Within +/- 15 cm from center of envelope in X and Y axes, +/- 3 cm in Z axis
Envelope	100 cm x 100 cm x 15 cm
Propulsion Systems	NONE
Fluid Systems	NONE
AOCS	Reaction wheels and magnetic torque coil control, GPS, thermal sensors, and inertial navigation.
Electrical Generation	Solar Cells
Electrical Storage	Rechargeable Lithium-Ion batteries. Qty 32: NCR18650B Panasonic Cells
Identification of any other sources of stored energy	NONE
Identification of any radioactive materials on board	NONE

Table 3: Summary of Spacecraft Parameters

2.1.1 Description of Propulsion Systems

None.

2.1.2 Description of attitude control system

The Lynk satellite attitude determination and control system consist of a processor, GPS receiver, sun sensors, gyroscopes, magnetometers, thermal IR sensors, reaction wheels, and integrated torque coils. Primary attitude knowledge is provided by the magnetometers, gyroscope, thermal IR sensors, and a GPS-based magnetic field model. Primary attitude control is provided by the torque coils and reaction wheels.

2.1.3 Description of normal attitude of the spacecraft with respect to the velocity vector

The nominal attitude of the Lynk satellite is an LVLH orientation with the antenna, aligned with the spacecraft z-axis, pointed down toward the nadir direction. An attitude control program will use the reaction wheels to maintain desired spacecraft orientation and the torque coils to prevent the reaction wheels from saturating.

The spacecraft is also capable of three-axis inertial control and can point dynamically to any inertial vector in space for inertial holds, high drag and low drag attitudes, sun pointing, or low-rate slews to point antennas at static locations on the Earth.

2.1.4 Description of any range safety or other pyrotechnic devices

None.

2.1.5 Description of the electrical generation and storage system

Energy generation is accomplished using body mounted solar panels on +x, -x, +y, -y, and +z faces of the spacecraft body. Energy storage is accomplished using Li-ion battery cells in an 8S1P (8 in series, 1 parallel) electrical configuration. Physically the cells are separated into four packs with eight cells in each pack. The packs are physically separated within the satellite.

Each Lynk satellite utilizes 32 Li-Ion cells to provide the overall voltage of the spacecraft of 28V. The cells are recharged by the solar cells mounted on the spacecraft. Power management and distribution is provided by the spacecraft-level electrical power system and pack-level battery protection circuitry.

3 ASSESSMENT OF SPACECRAFT DEBRIS RELEASED DURING NORMAL OPERATIONS

Lynk has assessed and limited the amount of debris released in a planned manner during normal operations. There is no intentional release of any object during normal operations.

Parameter	Value
Identification of any object (>1mm) expected to be released from the spacecraft at any time after launch	**None**
Rationale/necessity for release of object	N/A
Time of release of each object, relative to launch time	N/A
Release velocity of each object with respect to spacecraft	N/A
Expected orbital parameters of each object after release	N/A
Calculated orbital lifetime of each object	N/A
Compliance 4.3-1 Mission related debris passing through GEO	COMPLIANT
Compliance 4.3-2 Mission related debris passing through LEO	COMPLIANT

Table 4: Summary of Spacecraft Debris Released During Normal Operations

4 ASSESSMENT OF SPACECRAFT POTENTIAL FOR EXPLOSIONS AND INTENTIONAL BREAKUPS

Lynk 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.

4.1 Potential causes of spacecraft breakup during deployment and mission operations

There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.

4.2 Summary of failure modes and effects analysis of all credible failure modes

There are four Lithium-Ion battery packs aboard each satellite which are 92 W*hrs each and represent the only credible failure mode during which stored energy could be released. The main failure modes associated with Lithium-Ion batteries result from overcharging, over-discharging, internal shorts, and external shorts.

Overcharging, under-discharging, and external shorts are prevented by the solar-battery charger protection circuitry on each battery pack. The over current protection is set to 10 Amps. The battery overcharge protection limits both charging current and voltage.

Over-discharging is prevented by a low voltage disconnect and a 10 Amp current limiter.

Each battery pack contains eight lithium-ion cells wired in series in an aluminum housing to create a robust 28 Volt supply. The four batteries in each spacecraft are designed to be mechanically integrated into the spacecraft with > 4 inches separating the physical battery packs. Furthermore, each pack is thermally heat sunk to a separate heat sink on opposite sides of the spacecraft. In the unlikely event that one battery pack experiences an internal short, the batteries are separated by > 4 inches and thermally isolated with enough separation to eliminate the possibility of thermal runaway in one battery from causing thermal runaway in another battery.

Furthermore, in the case of a cell experiencing a catastrophic failure event (e.g., overcharge to the point of venting, or internal/external short, resulting in overheating and/or gas venting), the battery-level and cell-level safety protections further mitigate the probability of failure propagation. The cells are designed to vent out the top in the event of over-heating/over-pressure through the positive terminal (button cap). In the unusual case where cell rupture in the sidewall occurs, the pack-level design includes physical aluminum barriers between cells and a 20-mil compliant gap filling material between each cell and the aluminum housing.

Overall, the physical aluminum separators will prevent a failure from propagating between cells and the compliant material creates room for venting in the case of overpressure. There are also vent holes in the capture plates at the bottom/top of the battery packs to allow for venting in the case of over-pressure.

4.3 Detailed plan for any designed spacecraft breakup

There are no planned breakups.

4.4 List of components which shall be passivated at End of Mission (EOM)

All RF transmitters and beacons will be disabled by default. Satellite transmissions are only initiated by time-based stored commands on the ground and self-terminate based on an internal timer. Additionally, all RF transmissions from the satellite can be disabled by command from the ground. All RF transmitters will be passivated at the End of Mission.

Reaction wheels will be de-spun to their zero-momentum state by the torque coils prior to End of Mission and powered off. All batteries will be drained and passivated at the End of Mission.

4.5 Rationale for all items which are required to be passivated, but cannot be due to their design

None.

4.6 Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4

Requirement 4.4-1:

Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon:

> *For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).*

Compliance statement:

Required Probability: 0.001

Expected probability: 0.000000 COMPLIANT

Requirement 4.4-2:

Design for passivation after completion of mission operations while in orbit about Earth or the Moon:

> *Design of all spacecraft and launch vehicle orbital stages shall include the ability to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or post mission disposal or control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).*

Compliance statement:

The probability of a battery explosion is incredibly low, and, due to the very small mass of the satellite, low individual battery capacity, and its short orbital lifetime the effect of a highly unlikely explosion on the far-term LEO environment is negligible. Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4 shows that with a maximum orbital lifetime of 15.15 years, the *Shannon* satellite is compliant.

Requirement 4.4-3:
Limiting the long-term risk to other space systems from planned breakups:

Compliance statement:
This requirement is not applicable. There are no planned breakups.

Requirement 4.4-4:
Limiting the short-term risk to other space systems from planned breakups:

Compliance statement:
This requirement is not applicable. There are no planned breakups.

5 ASSESSMENT OF SPACECRAFT POTENTIAL FOR ON-ORBIT COLLISIONS

Lynk has assessed and limited the probability of the spacecraft becoming a source of debris by collisions with ***large*** debris or other operational space stations.

Lynk has assessed and limited the probability that the spacecraft will become a source of debris by collision with ***small*** debris or meteoroids that would cause loss of control and prevent disposal.

Lynk is aware that the orbit location of the satellite will be in the LEO environment where other spacecraft operators operate their orbiting assets. Firstly, Lynk has taken care to design the spacecraft to minimize the potential for collisions. Additionally, Lynk has several mechanisms in place to track the location and changing trajectory of its satellite while on orbit. Using NORAD TLEs, and on-board GPS, as mechanisms for satellite tracking Lynk can predict trajectory paths for the satellite and predict possible conjunctions well in advance of any actual conjunction events taking place. In the unlikely event of a conjunction event, Lynk would coordinate with the satellite operator of the spacecraft with which we could have a conjunction to determine what maneuvers, if any, are required to be made by either party to further reduce, or completely eliminate, the probability of that conjunction.

Furthermore, Lynk is aware that the operational orbit of the spacecraft is above that of the International Space Station (ISS), which is an inhabitable spacecraft in the LEO environment. The Lynk satellite will have to transit through an orbital altitude which is common with the ISS during its de-orbit phase. To eliminate any chance of conjunction with the ISS, Lynk has employed an operational strategy to de-orbit the satellite using a high drag attitude maneuver, which will bring the satellite to demise within 3.38 years. Lynk can accurately predict the trajectory of the spacecraft under this high drag attitude and continue to refine the prediction based on satellite tracking telemetry (from on board GPS and NORAD). As the trajectory is refined, Lynk can refine the attitude of the satellite to modify the trajectory such that its distance away from the ISS during its transition through the ISS altitude occurs at a distance that is comfortable to NASA. Lynk intends to coordinate both the tracking and planned orbit trajectory of the Lynk satellite as it makes its atmospheric re-entry upon end of life.

Since the Lynk spacecraft does not host a propulsion system, Lynk will not perform any propulsive orbital maintenance of its orbit. The satellite can increase or decrease the drag profile of its trajectory to articulate its trajectory, if needed, but the satellite orbits will for the most part simply be tracked (via on board GPS and NORAD) and monitored for safety with respect to conjunction. The accuracy of the tracked orbital parameters of the satellite will be limited by the accuracies of the TLEs provided by NORAD. Lynk's spacecraft TLEs will be published publicly by NORAD, and Lynk is willing to share orbit position and velocity telemetry with third parties as needed to ensure the trajectory of the satellite does not pose any risks to any other LEO assets.

Lynk certifies that upon written receipt of a space situational awareness conjunction warning, Lynk 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 will include and 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 to assist in avoiding any conjunctions.

5.1 Assessment of spacecraft trackability

Lynk's spacecraft will be operating in low-Earth orbit and is presumed trackable by the fact that the satellite is larger than 10 cm in its smallest dimension, and does not intend to deploy any objects, small or large.

Lynk intends to identify the satellite following deployment using a variety of methods. Firstly, each satellite is equipped with a redundant GPS receiver, which telemeters the GPS position vector of the satellite on downlink TT&C channels. This telemetry can be received at Lynk Command and Control in Falls Church, VA, either through the GlobalStar EyeStar relay link, or S-Band ground station links. Additionally, the launch provider will provide inertial state vectors for deployment of the satellites, which will be used initially by NORAD to track the Lynk satellite TLEs. After commissioning, and in the event that multiple satellites are deployed from the same launch vehicle, these TLEs will be verified or updated based on Lynk data received by telemetry downlink. Finally, during ground station overpasses, Doppler and Ranging measurements can be leveraged to further refine orbit determination computations and assist in more accurate satellite tracking telemetry.

Prior to deployment, the Lynk satellite will be registered with the 18th Space Control Squadron or successor entity. Additionally, Lynk plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity. Lynk is also willing to share trackability information with other entities that engage in space situational awareness or space traffic management functions, and/or other operators on an as-needed basis (e.g. to assist in conjunction resolution, etc.).

5.2 Assessment of spacecraft proximity operations

There are no planned proximity operations for the Lynk spacecraft.

5.3 Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2:

Requirement 4.5-1:

Limiting debris generated by collisions with large objects when operating in Earth orbit: For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001 (Requirement 56506).

Compliance statement: (Large Object Impact and Debris Generation Probability)
Required Probability: 0.001
Expected probability: 4.9624E-06   COMPLIANT
(Appendix A demonstrates compliance with the above via A DAS 3.1.0 log.)

<u>Requirement 4.5-2:</u>

Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit: For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post-mission disposal requirements is less than 0.01 (Requirement 56507).

<u>Compliance statement:</u> (Small Object Impact and Debris Generation Probability)
Required Probability: 0.01
Expected probability: 5.7380E-04 COMPLIANT
(Appendix A demonstrates compliance with the above via A DAS 3.1.0 log.)

6 ASSESSMENT OF SPACECRAFT POSTMISSION DISPOSAL PLANS AND PROCEDURES

6.1 Description of spacecraft disposal option selected

The satellite will de-orbit naturally by atmospheric re-entry. No propulsion system is used, or needed, for re-entry.

The spacecraft will assume a high drag orientation to support more rapid re-entry of the satellite. In the event that the spacecraft completely fails, the spacecraft will naturally de-orbit in a timeline that is compliant with the Commission's rules.

The atmospheric re-entry of the Lynk satellite will be uncontrolled. Due to the altitude of the Lynk satellite, analyzed under both the lowest and highest ballistic coefficient attitudes, there is a 100% probability of successful disposal and atmospheric reentry of the spacecraft in under 25 years.

6.2 Plan for any spacecraft maneuvers required to accomplish post mission disposal:

None.

6.3 Calculation of area-to-mass ratio after post mission disposal:

Spacecraft Mass:	~40 kg (dry mass)
Cross-sectional Area:	0.15 m^2 (min in notional orientation) 1.0 m^2 (max in high drag orientation)
Area to mass ratio:	(0.15 m^2)/(40 kg) = 0.00375 m^2/kg (min) (1.0 m^2)/(40 kg) = 0.025 m^2/kg (max)

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5:

Requirement 4.6-1:

Disposal for space structures passing through LEO: A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods: (Requirement 56557)

a. Atmospheric reentry option:

- *Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or*
- *Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.*

b. Storage orbit option:

- *Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.*

c. Direct retrieval:

- *Retrieve the space structure and remove it from orbit within 10 years after completion of mission.*

Compliance statement:

The orbit used for disposal of structure analysis for the satellite sun-synchronous orbit is a worst-case orbit of 525 km. All orbits below this will have a lower orbital lifetime. The orbital lifetime is predicted to be 15.15 years in the nominal low-drag orientation and 3.38 years in a high-drag orientation; COMPLIANT.

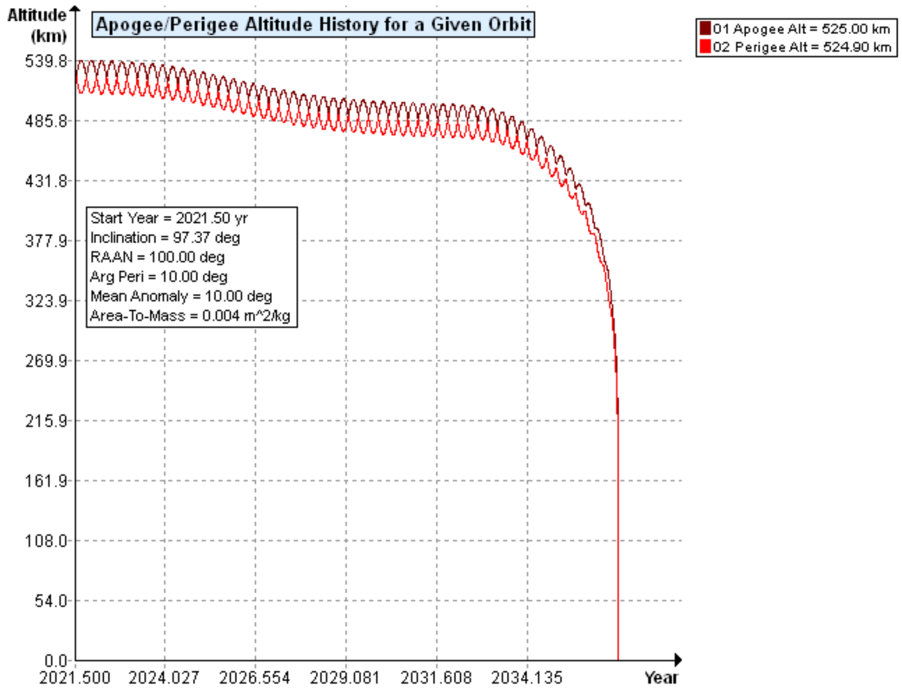

Figure 1 - Shannon 525 km SSO Satellite Deorbit Lifetime (Low-Drag Orientation)

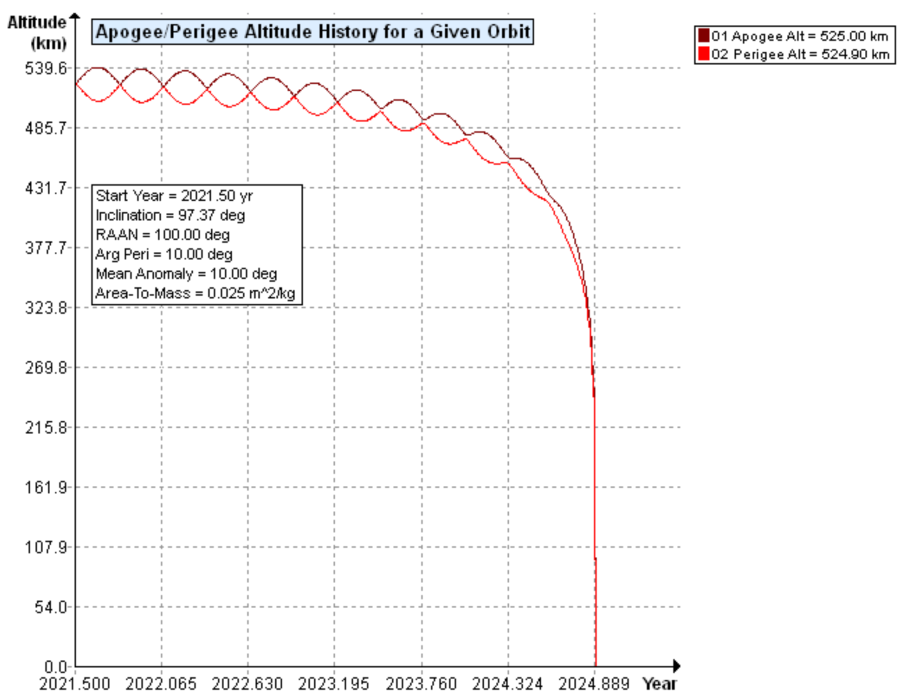

Figure 2 - Shannon 525 km SSO Satellite Deorbit Lifetime (High-Drag Orientation); 3.8-year max orbital lifetime

Requirement 4.6-2:
Disposal for space structures near GEO.

Compliance statement:
Not applicable. The *Shannon* satellite operates in LEO.

Requirement 4.6-3:
Disposal for space structures between LEO and GEO.

Compliance statement:
Not applicable. The *Shannon* satellite operates in LEO.

Requirement 4.6-4:
Reliability of Post-mission Disposal Operations.

Compliance statement:
Not applicable. The satellite will reenter passively without the need for post mission disposal operations within the allowable timeframe. Lynk may choose to orient the spacecraft to a high-drag attitude to speed reentry, but failing either of those options, the satellite will still deorbit passively within 15.15 years.

7 ASSESSMENT OF SPACECRAFT REENTERY HAZARDS

7.1 Assessment of spacecraft compliance with Requirement 4.7-1:

Limit the risk of human casualty: The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules.

Requirement 4.7-1-a:

a. *For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).*

Compliance statement:

DAS v3.1.0 reports that the Lynk satellite design is COMPLIANT with the requirement. The vehicle is primarily composed of Aluminum and PCB (Fiberglass) material. Only one of the components is predicted to survive re-entry, with a predicted Total Debris Casualty Area of 1.844945. The risk of human casualty is estimated to be 1:41900.

(Appendix A located in the back of this report contain the DAS 3.1.0 modeling input and results.)

Requirement 4.7-1-b:

b. *For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627).*

Compliance statement:

Not applicable. No controlled reentry is planned.

Requirement 4.7-1-c:

c. *For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4-b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628).*

Compliance statement:

Not applicable. No controlled reentry is planned.

8 ASSESSMENT FOR TETHER MISSIONS

Not applicable. There are no tethers aboard the *Shannon* satellite.

APPENDIX A - DAS 3.1.0 LOG FOR SSO ORBIT

01 22 2021; 16:52:13PM   Activity Log Started
01 22 2021; 16:52:13PM   Opened Project C:\Users\lab\Desktop\DAS Projects*Shannon*\
01 22 2021; 16:52:17PM   Processing Requirement 4.3-1:   Return Status : Not Run

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-1 ===============
01 22 2021; 16:52:20PM   Processing Requirement 4.3-2: Return Status : Passed

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-2 ===============
01 24 2021; 22:23:15PM   Processing Requirement 4.5-1:   Return Status : Passed

==============
Run Data
==============

INPUT

Space Structure Name = *Shannon*
Space Structure Type = Payload
Perigee Altitude = 524.800 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.460 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0037 (m^2/kg)
Start Year = 2021.500 (yr)
Initial Mass = 40.000 (kg)
Final Mass = 40.000 (kg)
Duration = 5.000 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 4.9624E-06
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==============

=============== End of Requirement 4.5-1 ===============

01 24 2021; 22:23:20PM Project Data Saved To File
01 24 2021; 22:38:29PM Requirement 4.5-2: Compliant

===
Spacecraft = *Shannon*
Critical Surface = none
===

INPUT

Apogee Altitude = 525.000 (km)
Perigee Altitude = 524.800 (km)
Orbital Inclination = 97.460 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0037 (m^2/kg)
Initial Mass = 40.000 (kg)
Final Mass = 40.000 (kg)
Station Kept = No
Start Year = 2021.500 (yr)
Duration = 5.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 1.000 (g/cm^2)
CS Surface Area = 0.0010 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 1.000 (g/cm^2) Separation: 1.000 (cm)

OUTPUT

Probability of Penetration = 5.7380E-04 (5.7397E-04)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

=============== End of Requirement 4.5-2 ===============

01 24 2021; 22:38:31PM Processing Requirement 4.6 Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = *Shannon*
Space Structure Type = Payload

Perigee Altitude = 524.800000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.460000 (deg)
RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003750 (m^2/kg)
Start Year = 2021.500000 (yr)
Initial Mass = 40.000000 (kg)
Final Mass = 40.000000 (kg)
Duration = 5.000000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 488.927066 (km)
PMD Apogee Altitude = 518.068387 (km)
PMD Inclination = 97.553270 (deg)
PMD RAAN = 2.597081 (deg)
PMD Argument of Perigee = 82.477352 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 488.927066 (km)
Suggested Apogee Altitude = 518.068387 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2036 (yr)
Requirement = 61
Compliance Status = Pass

==============

=============== End of Requirement 4.6 ===============
01 24 2021; 22:38:42PM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 1

name = *Shannon*
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 40.000000
Thermal Mass = 40.000000
Diameter/Width = 1.000000
Length = 1.000000
Height = 0.150000

name = Wheels
quantity = 4
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.500000
Thermal Mass = 0.500000

Diameter/Width = 0.055000
Length = 0.027500

name = I-Beam Outer
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 0.417000
Thermal Mass = 0.417000
Diameter/Width = 0.070000
Length = 0.520000
Height = 0.040000

name = I-Beam Inner
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.915000
Thermal Mass = 0.915000
Diameter/Width = 0.070000
Length = 0.360000
Height = 0.040000

name = Pentaplexer
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.200000
Thermal Mass = 2.200000
Diameter/Width = 0.152000
Length = 0.206000
Height = 0.038000

name = Assorted Electronics
quantity = 1
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 1.440000
Thermal Mass = 1.440000
Diameter/Width = 0.200000
Length = 0.300000

name = Bus Structure
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 15.240000
Thermal Mass = 15.240000

Diameter/Width = 1.000000
Length = 1.000000
Height = 0.150000

name = Batteries
quantity = 32
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.014000
Thermal Mass = 0.014000
Diameter/Width = 0.018500
Length = 0.065300

*************OUTPUT****
Item Number = 1

name = *Shannon*
Demise Altitude = 77.999084
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Wheels
Demise Altitude = 57.253765
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = I-Beam Outer
Demise Altitude = 75.424934
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = I-Beam Inner
Demise Altitude = 70.422615
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Pentaplexer
Demise Altitude = 60.531876
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Assorted Electronics
Demise Altitude = 71.488602
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bus Structure
Demise Altitude = 0.000000
Debris Casualty Area = 1.844945
Impact Kinetic Energy = 4032.371826

****

name = Batteries
Demise Altitude = 76.740898
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

============== End of Requirement 4.7-1 ===============
01 24 2021; 22:38:42PM	Project Data Saved To File