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TBD	1.0	FM1 - Orbital Debris Assessment Report (ODAR)	None

FM1 - Orbital Debris Assessment Report

Release Date: 3/14/25

PROJECT: FM1

In accordance with NPR 8715.6A, this report is presented as compliance with the required reporting format per NASA-STD-8719.14, Appendix A

DAS Software used in this analysis: DAS v3.2.6.

AST SpaceMobile, Inc. • Midland Intl. Air & Space Port, 2901 Enterprise Lane • Midland, TX 79706 • U.S.A.

Document Number	Revision	Title	Security
TBD	1.0	FM1 - Orbital Debris Assessment Report (ODAR)	None

VERSION CONTROL

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CHANGE LOG

Issue	Section	Effective Date	Change Description
1.0	All	3/14/25	New Document

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Table 1 - Orbital Debris Self-Assessment Report Evaluation: FM1 Mission

Reqm't #	Launch Vehicle					Spacecraft				Comments
	Compliant	N/A	Not Compliant	Incomplete	Standard Non-Compliant	Compliant	N/A	Not Compliant	Incomplete	For all incompletes, include risk assessment (low, Medium, or high risk) of non-compliance& Project Risk Tracking #
4.3-1.a 25 years						✓				
4.3-1.b <100 object year limit						✓				
4.3-2 GEO +/- 200Km							✓			
4.4-1 < 0.001 Explosion Risk						✓				
4.4-2 Passive Energy Source						✓				
4.4-3 Limit Long-Term Risk						✓				
4.4-4 Limit BU Short term Risk						✓				
4.5-1 <0.001 10cm Impact Risk						✓				
4.5-2 Postmission Disposal Risk						✓				
4.6-1(a) Atmosphere Energy Option						✓				
4.6-1(b) Storage Orbit							✓			
4.6-1(c) Direct Retrieval							✓			
4.6-2 GEO Disposal							✓			
4.6-3 MEO Disposal							✓			
4.6-4 Disposal Reliability						✓				
4.6-5 Summary of DeOrbit						✓				

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4.7-1 Ground Population Risk						✓				
4.8-1 Tethers Risk							✓			

Table 2 - In-Flight EOMP Evaluation: FM1 Mission

Reqm't #	Spacecraft			EOMP Comments
	Compliant	N/A	Not Compliant	
4.3-1.a 25 years	✓			
4.3-1.b <100 object year limit	✓			
4.3-2 GEO +/- 200Km		✓		
4.4-1 < 0.001 Explosion Risk	✓			
4.4-2 Passive Energy Source	✓			
4.4-3 Limit Long-Term Risk	✓			
4.4-4 Limit BU Short term Risk	✓			
4.5-1 <0.001 10cm Impact Risk	✓			
4.5-2 Postmission Disposal Risk	✓			
4.6-1(a) Atmosphere Energy Option	✓			
4.6-1(b) Storage Orbit		✓		
4.6-1(c) Direct Retrieval		✓		
4.6-2 GEO Disposal		✓		
4.6-3		✓		

MEO Disposal				
4.6-4 Disposal Reliability	✓			
4.6-5 Summary of DeOrbit	✓			
4.7-1 Ground Population Risk	✓			
4.8-1 Tethers Risk		✓		

1. Program Management and Mission Overview

Mission Directorate: AST SpaceMobile Inc.

Engineer Director: Huiwen Yao

Systems Engineering Lead: David Wolfe

Project Manager: Mark McLaren

Schedule of mission design and development milestones (if applicable) from NASA mission selection through proposed launch date, including spacecraft PDR and CDR (or equivalent) dates:

PDR	May 2024
CDR	February 2025
Integration to GSLV Mk3	May 2025
Launch to LEO:	June 2025

Mission Overview:

The BlueBird Block 2 satellite (FM-1) is a technology pathfinder for AST's BlueBird constellation of commercial direct to cellular satellites. This satellite is an evolution of the BlueBird Block 1 satellites launched in September of 2024, with a larger phased array and an enhanced satellite bus (ControlSat) to support the larger phased array and higher throughput than the Block 1 satellites. The satellite is intended to demonstrate enhanced reliability array deployments as well as higher capability bus components (such as payload antennas). The satellite is intended to remain on orbit for up to 7 years before de-orbiting, providing cellular service to multiple regions around the world.

Launch vehicle and launch site: ISRO GSLV Mk3, launching out of Satish Dhawan Space Center via NSIL

Proposed launch date: June 2025

Mission duration: Up to 7 years operational service life

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination:

GSLV Mk3 will direct inject FM-1 to a target circular orbit of 520 km altitude at an inclination of 53 degrees.

Apogee: 520 km

Perigee: 520 km

Inclination: 53 degrees

Interaction or potential physical interference with other operational Spacecraft: The main risks of this satellite are collisions with debris, satellites, and micrometeorites.

2. Spacecraft Description

The FM1 system's mission is to deploy a large phased array into LEO which will enable broadband connections for standard terrestrial cellular phones in areas not served by conventional cellular towers. The satellite consists of the ControlSat which is the cylindrical main body of 2.15m radius and 1.6m height that hosts all satellite subsystems required for telemetry, tracking, and commanding (TT&C), attitude determination and control, and propulsion. After separation from the launch vehicle, activation, detumble, and checkout, the ControlSat deploys solar panels of approximately 30 m^2 area from the zenith cylinder face in the anti-velocity direction and a phased array antenna of approximately 223 m^2 in the velocity direction.

FM1 will contain the following systems:

- ControlSat Structure and Mechanisms
- Propulsion (Hall Current Thrusters)
- Command and Data Handling (C&DH)
- Electrical Power System (EPS)
- Attitude and Orbit Control System (AOCS)
- Telemetry, Tracking, and Command System (TT&C)
- QV Payload
- Phased Array

Total satellite mass at launch, including all propellants and fluids: 5850 kg

Dry mass of satellite at launch, excluding solid rocket motor propellants: 5830 kg

Description of all propulsion systems (cold gas, monopropellant, bi-propellant, electric, nuclear):

FM-1 has an electric propulsion system using Xenon propellant. This system consists of 2 separate, independent propulsion modules, each containing a thruster, PPU, and propellant tanks/distribution. These systems have flight heritage on prior BlueBird satellites as well as other on-orbit systems. The propellant distribution is a simple blow-down design.

Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes.

There will be 20kg of Xenon gas at pressure of approximately 1,000 psi. Final loading of Xenon will be performed at the launch site prior to integration with the launch vehicle.

Fluids in Pressurized Batteries:

None. FM1 uses unpressurized standard COTS lithium-ion battery cells.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector:

FM1 will implement an attitude control system based off multiple magnetorquers and reaction wheels. Attitude determination uses redundant internal IMUs, magnetometers, and star trackers. The attitude control and determination system has multiple fault tolerance to loss of attitude control and determination at the component level.

Description of any range safety or other pyrotechnic devices:

None. The FM1 satellite will be launched powered off. RBF pins and umbilical power detection are used to prevent accidental deployment or initiation on the ground. During launch, separation detection breakwires are used to prevent accidental deployment or initiation. The satellite autonomously powers up after positive indication of separation from the launch vehicle. Separation systems are initiated by the launch vehicle.

Description of the electrical generation and storage system:

ControlSat (bus) and the Phased Array electronics have separate, independent power generation and storage systems. As the Phased Array electronics have no responsibility to maintain overall satellite health, only the ControlSat (bus) systems are described herein.

The ControlSat electrical power system (EPS) is responsible for the storage of electrical energy, power generation, power management, and power distribution to the loads. It is made up of a lithium-ion batteries, photovoltaic cells for power generation, and the power control and distribution unit (PCDU) for the power management and distribution functions. The EPS is used to power On and Off the spacecraft, as well as individual loads.

The battery is a secondary (rechargeable) lithium-ion battery made from COTS 18650 cells. The battery is responsible for energy storage and sets the voltage of the unregulated bus. The battery will connect to the PCDU unit for main bus power.

Each battery assembly weighs 22 kg, for a total of 1,440 cells in the ControlSat. Each assembly is approximately 400 mm x 388 mm x 92 mm. The battery system is sized to be single fault tolerant to loss of battery module against the system failure of loss of mission.

The ControlSat solar panel assembly consists of a single body mounted solar panel and multiple deployable panels. Each panel uses silicon cells. The system is power positive in any single failure condition, including failure of the gimbal, at an end-of-life timeline of 7 years.

Identification of any other sources of stored energy not noted above:

None.

Identification of any radioactive materials on board:

None.

3. Assessment of Spacecraft Debris Released during Normal Operations

Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material:

None. There are no intentional releases.

Rationale/necessity for release of each object:

N/A

Time of release of each object, relative to launch time:

N/A

Release velocity of each object with respect to spacecraft:

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Expected orbital parameters (apogee, perigee, and inclination) of each object after release:

N/A

Calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO):

N/A

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v2.6.3)

Requirement 4.3-1, Mission Related Debris Passing Through LEO:

COMPLIANT. No debris released >1mm, while passing through LEO.

Requirement 4.3-2, Mission Related Debris Passing Near GEO:

COMPLIANT. No debris released will transverse GEO.

4. Assessment of Spacecraft Intentional Breakups and Potential for Explosions

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.

Summary of failure modes and effects analyses of all credible failure modes, which may lead to an accidental explosion:

AST has assessed and limited the probability of accidental explosions occurring. The two sources of on-orbit explosions are propellant tanks and batteries, both of which will be continuously monitored throughout the spacecraft lifetime for failures. The batteries are continuously monitored by an electrical power system (EPS) module to avoid over-charging/discharging. Should battery operation fall outside of an acceptable range it will be discharged and taken out of service, removing any stored energy it contained. All batteries on-board the ControlSat will have a 1.5 mm aluminum casing and thermally isolated to mitigate thermal loads. Additionally, the batteries will have protective circuitry to regulate safe and nominal voltage and current levels.

The propellant for the electric propulsion system is an inert and non-reactive noble gas and does not present a source of energy conversion in the event of a gas leak. The pressurized propellant tank will be continuously monitored with frequent downlink of state-of-health telemetry. Propellant safety measures include a system of pressure control and relief valves, with complete thermal isolation and temperature control. Any stored energy remaining at the spacecraft’s end-of-life will be removed via depletion of the propellant tank and permanently discharging the on-board batteries.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:

There are no planned breakups other than during atmospheric entry for disposal.

List of components which shall be passivated at End of Mission (EOM) including method of passivation and amount which cannot be passivated:

Reaction Wheels – despin using magnetic torque rods

Batteries – discharged at EOM

Xenon propellant can be vented on orbit manually. If excess propellant is available at end of life, thrust will be applied in the anti-velocity vector to reduce de-orbit times until propellant is exhausted.

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:

COMPLIANT.

Required Probability: 0.001.

Expected Probability: 0.000.

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:

COMPLIANT. Xenon tank, RWA, and lithium-ion batteries will be passivated and batteries depleted prior to atmospheric reentry.

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

Compliance statement:

COMPLIANT. There are no planned breakups.

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

Compliance statement:

COMPLIANT. There are no planned breakups.

5. Assessment of Spacecraft Potential for On-Orbit Collisions

25.114(d)(14)(ii) Assessment of Collisions with Small Debris

AST has assessed and limited the probability of one of its satellites becoming a source of debris by collisions with meteoroids and small orbital debris (MMOD) that could cause loss of control and prevent post-mission disposal. While the payload of the spacecraft employs a large platform phased array, this array itself is not utilized in the process of attitude control or orbit maintenance. These tasks are handled by a centralized ControlSat, comprising torque rods, reaction wheels and a propulsion system. Post-mission disposal is accomplished through ballistic orbital decay, and as such, any small debris damage, even if it resulted in the ControlSat being non-operational, would not prevent compliance with the applicable post-mission disposal requirements. NASA's DAS Orbit Lifetime/Dwell Time generates calculated orbit lifetimes of 2.93 years for the combined ControlSat and Phased Array in a loss of control scenario, where spacecraft geometry and center of gravity results in the spacecraft adopting a similar drag orientation as under nominal operations and thereby reentering within the 5-year requirement.

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

(1) Satellite position within a given orbital plane will be continuously monitored as control is handed off every eight hours across multiple Spacecraft Operations Centers (SOCs) located in Lanham, MD, USA; Barcelona, Spain; and Adelaide, Australia. The system is equipped with an electric propulsion system that will be used to perform collision avoidance maneuvers with large debris or other operational space stations. In the event of a propulsion system failure, an increased drag "pitch-up" maneuver can be executed to perform collision avoidance. The collision risk may be assumed to be zero during any period in which the space station will be maneuvered effectively to avoid colliding with large objects. However, in the event of a failure of this system, the NASA DAS software was used to determine the probability of collision of an AST spacecraft with a large (>10 cm) secondary object over the mission lifetime and de-orbit phase. This probability was assessed separately for the phased array payload and the ControlSat subsystem with DAS due to their different geometries and then combined into an overall probability. In nominal operational mode, the phased array is aligned edge on with the spacecraft's velocity vector, presenting a very small effective cross-section. For the phased array, the probability of a collision is 1.88E-5, or approximately 1:53,200, and for the ControlSat the probability of collision is 9.81E-5, or approximately 1:10,100, giving a combined probability of approximately 1:8,550, which is compliant with the target threshold of 1:1,000. The FM1 spacecraft geometry and center of gravity are oriented such that, in case of loss of all attitude determination or control, the phased array will rotate below the ControlSat, again presenting one edge to the velocity vector, minimizing its effective cross-section resulting in identical collision probabilities.

(2) At the operational altitude of the AST spacecraft there are currently approximately 160 functioning satellites that cross the orbit at various periods, approximately 70 of which have masses greater than 10 kg. The mass is merely noted as representative of size. This is not an unusually high number for any particular LEO orbital altitude. Approximately 90 of these are operated by government or commercial entities within the United States with the rest operated internationally. While the probability of collision over the mission lifetime at this altitude is extremely low, efforts will be made to identify points of contact for each operator in the event that a conjunction risk warrants the exchange of higher precision ephemeris information to aid in risk assessment and to help determine an appropriate course of action. Primary measures of collision avoidance are discussed below.

(3) During the de-orbit phase of the AST spacecraft, it will pass through the operational altitudes of the International Space Station and the Tiangong Space Station. Several future inhabited space stations are planned at these lower altitudes over the next decade. To establish best practices for collision avoidance with these space stations – as well as other Earth-orbiting objects generally (inhabited or not), AST has entered into a Space Act Agreement with NASA, formalizing AST's commitment to these best practices. Elements of these best practices include:

   a. Abiding by all collision avoidance (CA) best practices as documented in the NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook;

   b. Working collaboratively with NASA to establish and maintain a CA concept of operations that provides acceptable safety-of-flight to both the NASA and AST's satellite fleet;

   c. Supporting both regular and emergency coordination meetings to discuss and jointly resolve CA-related operational issues;

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d. Providing planned maneuver notifications to ensure situational awareness of any insertion, orbit maintenance, risk mitigation, constellation phasing, or deorbit activities;

e. Coordinating with NASA in the event of a high interest event with an active NASA mission to ensure communication of risk mitigation activities;

f. Coordinating with NASA on AST covariance realism to aid in estimating errors and uncertainties in the distribution of the relative positions of the conjuncting objects;

g. Providing predicted and as-flown ephemerides to facilitate state error and covariance realism evaluations;

h. Exchanging other astrodynamics and relevant bus data (e.g., attitude quaternions, on-board GPS position data) to allow other CA-related questions to be investigated;

i. Supporting technical exchange meetings, as necessary;

j. Supporting other collaborative analyses that address orbital safety questions of interest and relevance to both parties;

k. Updating maneuverability status on the 18 SDS file exchange website, Space-Track.org, as soon as practical for any AST asset that has become non-maneuverable;

l. Performing mission orbit operations in such a way as to avoid any notifiable conjunctions with ISS (within ±2 x ±25 x ±25 km radial, in-track, cross-track centered on the ISS);

m. Informing NASA as soon as possible of any changes to the AST CA process that may impact NASA.

n. Informing NASA as soon as possible of any changes to the AST mission profiles or orbital changes that may impact NASA;

o. Providing NASA information on raising and lowering operations to determine when collaboration is required for specific assets

(4) During mission operation, the orbital altitude – including perigee and apogee of the orbit – will be maintained to within ±1 km using the onboard propulsion system. Orbit inclination is not affected by leading order perturbations and is not expected to vary more than 1˚ over the mission and de-orbit lifetime. As an NGSO satellite with orbit inclination below 90˚, the right ascension of the ascending node will naturally drift westward continuously over the entire mission. Utilizing the onboard propulsion system, the orbit altitude can be changed at a rate of about 500 meters/day.

(5) Referring to (3)(a) above, AST certifies that it will abide by all collision avoidance (CA) best practices as documented in the NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook.

25.114(d)(14)(v) Trackability

AST spacecraft are trackable by a variety of government and commercially operated ground-based radar systems. In addition:

(A) Immediately following release from the launch vehicle, the satellites will broadcast a beacon signal that allows for the identification and active tracking of the spacecraft.

(B) Prior to deployment, each AST spacecraft will be registered with the 18th Space Control Squadron or successor entity.

(C) GPS receivers will provide precise satellite locations that will be used to maintain a precision ephemeris for each spacecraft. It has been demonstrated that the location of the BW3 satellite that is currently in orbit is known up to 12 hours in advance to within 10-20 meters using this approach. As with BW3, ephemeris data will be shared with the 18th Space Control Squadron or successor entity and with other operators with assets flying at the same orbital altitude. This data will also be made publicly available as Two-Line Element (TLE) sets through the CelesTrak website.

25.114(d)(14)(vi) Proximity Operations

For the FM1 mission, the LVA will remain attached to the launch vehicle. No proximity operations are expected as the kinetic energy imparted by the separation mechanism has been designed to create sufficient distance to prevent recontact.

25.114(d)(14)(vii) Post-mission Disposal

At the end of the planned mission life, the spacecraft will be de-orbited through atmospheric drag. While the FM1 spacecraft is compliant with the 5-year deorbit benchmark without reliance on post-mission disposal maneuvering, depending on propellant use during the mission additional propellant may be available to further reduce altitude and accelerate the natural de-orbit due to drag. AST endeavors to achieve disposal of each spacecraft in under 5 years and ideally in as short a time as possible.

(1) As stated in section 3.6 below, the overall probability of failure to achieve post-mission disposal over the mission lifetime and de-orbit phase due to MMOD impact is 0, as the deployed spacecraft structure presents sufficient cross-sectional area to deorbit naturally within the 5-year requirement, as analyzed by DAS 3.2.6.

(2) While a limited level of drag control during re-entry is possible, for conservatism it is assumed that the re-entry will be entirely uncontrolled. Demise of the spacecraft upon re-entry has been analyzed using the NASA DAS software and it has been determined that all component types are predicted to completely demise. As such, the spacecraft does not pose any casualty risk.

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v2.6.3, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):

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).

COMPLIANT.

Large Object Impact and Debris Generation Probability: 1.17E-04

Requirement 4.5-2: 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).

COMPLIANT.

Small Object Impact and Debris Generation Probability: 0.000. FM1 will reenter within post mission disposal requirement of 5 years even if ACS and Propulsion are disabled.

5.1 ODAR/EOMP Section 6: Assessment of Spacecraft Post-mission Disposal Plans and Procedures

Description of spacecraft disposal option selected: Two cases will be considered for this section. The first case is called "Nominal Deployment" in which

Case 1: *Nominal Deployment* The satellite will de-orbit due to the deployed phased array. There is no propulsion required to achieve reentry within post mission disposal requirement target of 5 years.

Case 2: *Failed Deployment* The satellite will de-orbit naturally by atmospheric re-entry. There is no propulsion system and burn at re-entry.

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

None.

Calculation of area-to-mass ratio after post mission disposal, if the controlled reentry option is not selected:

Case 1: *Nominal Deployment*

Spacecraft Mass: 5850 kg

Cross-sectional Area: 9.54E+01 m^2

Area to mass ratio: 9.54E+01 m^2 / 5850 kg = 1.63E-02 m^2/kg

Case 2: *Failed Deployment*

Spacecraft Mass: 5870 kg

Cross-sectional Area: 1.267E+01 m^2

Area to mass ratio: 1.267E+01 m^2 / 5850 kg = 2.167E-03 m^2/kg

Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-4 (per DAS v 2.1 and NASA-STD-8719.14 section):

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.

Analysis:

Case 1: *Nominal Deployment*

FM1 satellite reentry is COMPLIANT using Method "a." FM1 re-enter in 2.93 years after mission completion.

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Case 2: *Failed Deployment*

FM1 satellite reentry is COMPLIANT using Method "a." FM1 will re-enter in 22.3 years after failed deployment (analysis assumes an approximate random tumbling behavior). AST recognizes that DAS 3.6.2 is still checking validating against the 25-year rule which was superseded Sep 29, 2024 by the 5-year rule. As the failed deployment case represents a high unlikely scenario due to FM1's design redundancy, fault tolerance, and mission assurance estimates of over 99.8%, AST asserts compliance with the performance-based objective of the 5-year deorbit requirement.

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

Analysis: Not applicable. FM1 orbit is in LEO.

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

Analysis: Not applicable. FM1 orbit is in LEO.

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

COMPLIANT.

Analysis:

Case 1: *Nominal Deployment*

FM1 de-orbiting relies only on drag to achieve deorbit within post mission disposal requirements. FM1 re-enter in 2.93 years after mission completion.

Case 2: *Failed Deployment*

FM1 de-orbiting relies only on drag to achieve deorbit within post mission disposal requirements. FM1 re-enter in 22.3 years after mission completion.

5.2 ODAR/EOMP Section 7: Assessment of Spacecraft Reentry Hazards

Assessment of spacecraft compliance with Requirement 4.7-1:

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:

4.7-1, a) For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

Summary Analysis Results :

COMPLIANT.

DAS v2.6.3 reports that FM1 is compliant with the requirement. It predicts that no component on board has more than 15 joules of impact kinetic energy. The majority of FM1 including its components and the phased array will burn up on re-entry. As seen in the analysis outputs below, no major components are expected to survive reentry.

Table 3 - Reentry Data for ControlSat and PA

Reentry Data														
Row Num	Name	Parent	Qty	Material	Body Type	Thermal M	Diameter/	Length	Height	Status	Risk	Demise Al	Total DCA	KE
1	CONTROLSAT	0	1	Aluminum	Cylinder	2964	4.3	1.6		Complian	0		0	
2	PCDU	1	1	Aluminum	Box	28.78	0.4	0.4	0.3			61.1	0	0
3	RWA	1	12	Aluminum	Cylinder	8.35	0.46	0.175				71.9	0	0
4	MTQ	1	9	Iron	Box	12.5	0.1	0.781	0.1			59.3	0	0
5	SRM	1	1	Aluminum	Box	5	0.44	0.49	0.1			74.1	0	0
6	BATT	1	6	Aluminum	Box	21.45	0.389	0.399	0.091			57.5	0	0
7	PLM SLR ARR DEP - PANELS	1	8	Silicon	Box	0.47	1.385	1.65	0.1			78	0	0
8	PLM SLR ARR DEP - STRUCT	1	2	Graphite E	Box	12.96	2.87	3.3	0.2			77.7	0	0
9	PLM SLR ARR FIX - PANELS	1	6	Silicon	Box	0.76	1.16	1.8	0.1			78	0	0
10	PLM SLR ARR FIX - STRUCT	1	1	Graphite E	Box	23.22	3.2	3.6	0.2			77.3	0	0
11	MFC	1	1	Aluminum	Box	25.9	0.29	0.35	0.27			61.2	0	0
12	QV	1	3	Aluminum	Cylinder	21.2	0.7	0.3				70.6	0	0
13	LAT PLT	1	6	Aluminum	Flat Plate	50	1.6	2.25				65.8	0	0
14	ZEN RING	1	1	Aluminum	Cylinder	150	4.3	1.6				68.1	0	0
15	NAD PLT	1	8	Aluminum	Flat Plate	43.463	1.347	1.347				59.4	0	0
16	NAD STR	1	12	Aluminum	Box	28.976	0.5	0.5	0.1			55.8	0	0
17	NAD STF	1	10	Aluminum	Box	43.14	0.496	0.732	0.144			57.8	0	0
18	PROP	1	2	Aluminum	Box	16.86	0.5	0.5	0.1			64.9	0	0
19	PHASED ARRAY	0	1	Graphite E	Flat Plate	2863	12.838	15.398		Complian	0		0	
20	TILE BF NO GPS Electronics	19	1680	Polycarbo	Box	0.98	0.32	0.33	0.15			77	0	0
21	TILE BF NO GPS Structure	19	210	Graphite E	Box	2.9	0.647	1.302	0.25			76.9	0	0
22	TILE BF GPS Electronics	19	240	Polycarbo	Box	0.98	0.32	0.33	0.15			77	0	0
23	TILE BF GPS Structure	19	30	Graphite E	Box	2.9	0.647	1.302	0.25			76.9	0	0

5.2.1 ODAR/EOMP Section 7A: Assessment of Spacecraft Hazardous Materials

Not applicable. There are no hazardous materials on FM1 and no materials are expected to survive reentry.

5.3 ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers in the FM1 mission.

6.0 Orbital Debris Mitigation Requirements for Launch Vehicle

6.1 ODAR Sections 9-14: Launch Vehicle

Since the FM1 launch vehicle is managed by NSIL the orbital debris assessment for the launch vehicle will be performed by NSIL. The following note from NPR 8715.6A, Paragraph P.2.2, is applied, "*Note: It is recognized that NASA has no involvement or control in the design or operation of Federal Aviation Administration (FAA)-licensed launches or foreign or Department of Defense (DoD)-furnished launch services, and, therefore, these are not subject to the requirements in this NPR for the launch portion.*"

END of ODAR for FM1.

END OF THE DOCUMENT