Attachment A
(Orbital Debris Rule Compliance)

Keeping space safe and sustainable is paramount to Lockheed Martin. Consistent with this mission, the LM400 Radar Pathfinder (RPF) satellite will satisfy the FCC's orbital debris mitigation rules in 47 C.F.R. § 25.114(d)(14), as amended, to ensure safe design build, minimize collision risk, and achieve post-mission disposal success.[1]

Summary: The planned operational orbit parameters of the LM400 RPF satellite are: 450 km altitude, 42° inclination. The satellite measures approximately 98" x 56" x 50" in its on-orbit operational flight configuration. De-orbit disposal of the satellite at the conclusion of its operational mission will be performed by targeted atmospheric re-entry.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(i)	A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices, distinct from the space station launch vehicle, that may become a source of orbital debris	There is no planned release of debris from the satellite during on-orbit operations that may become a source of orbital debris.
25.114(d)(14)(ii)	A statement indicating whether the space station operator has assessed and limited the probability that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool	The probability that the satellite will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal is .0043, calculated using ESA MASTER 8.0.5 for orbital debris less than 10mm, NASA ORDEM 3.2 for orbital debris greater than 10mm, and the Grün model for micrometeoroids.

[1] *See generally Mitigation of Orbital Debris in the New Space Age*, Report and Order et al., 35 FCC Rcd 4156 at Appendix A (2020).

[2] For all calculations, Lockheed Martin used National Aeronautics and Space Administration (NASA) Debris Assessment Software v.3.2.6.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iii)	A statement that the space station operator 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. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application	Accidental explosion or release of liquids on-orbit after mission completion is mitigated through immediate de-orbit of the satellite to minimize time on-orbit. Upon completion of the operational mission, the satellite will perform up to 5 sequential de-orbit burns using an onboard propulsion system to de-orbit the satellite. Re-entry and breakup of the satellite will occur less than 30 minutes after the final de-orbit burn.
25.114(d)(14)(iv)	A statement that the space station operator has assessed and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations	See below.
25.114(d)(14)(iv)(A)	Where the application is for an NGSO space station or system, the following information must also be included	See below.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iv)(A)(1)	A demonstration that the space station operator has assessed and limited the probability of collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects	The probability of collision between the satellite and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the satellite, including any de-orbit phases, using DAS 3.2.6 is 1.27E-4.
25.114(d)(14)(iv)(A)(2)	The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision	There are no known collision risks in the intended orbit or any other satellites that share that orbit.
25.114(d)(14)(iv)(A)(3)	If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft	During de-orbit from its operational altitude of 450 km, the satellite will pass through the altitude of ISS (420 km) and Tiangong (393 km). Prior to any orbital maneuver that will result in the satellite transiting through these orbits, Lockheed Martin will coordinate with the 19th Space Defense Squadron to ensure the orbit will not result in conjunctions with or operational constraints to any inhabitable spacecraft.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iv)(A)(4)	The statement must disclose the accuracy, if any, with which orbital parameters will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *e.g.,* its propulsion system will not be used for orbital maintenance, that fact must be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. All systems must describe the extent of satellite maneuverability, whether or not the space station design includes a propulsion system	After achieving the planned orbital parameters for the mission, the satellite orbital parameters will be maintained between 410-455 km altitude. The satellite has propulsive capability that will be used for debris avoidance, conjunction mitigation, and de-orbit at end of mission.
25.114(d)(14)(iv)(A)(5)	The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator 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 should include, but are 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	Upon receipt of a space situational awareness conjunction warning, LMC will review and take all possible steps to assess the collision risk and mitigate if necessary. Operational responses may include 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/or modifying the satellite’s attitude and/or operations to avoid the conjunction.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iv)(B)	Where a space station requests the assignment of a geostationary orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap or touch. If so, the statement must include a statement as to the identities of those satellites and the measures that will be taken to prevent collisions	N/A
25.114(d)(14)(v)	A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, excluding deployable components. Where the application is for an NGSO space station or system, the statement shall also disclose the following	The satellite is presumed trackable as it operates in low-Earth orbit and measures 50” in its smallest dimension.
25.114(d)(14)(v)(A)	How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive	A state vector provided approximately 15 minutes after separation will be used to generate the initial two-line element set (TLE) for tracking and first acquisition. Orbit determination via GPSR telemetry will be used to generate ephemeris for SAA sharing for the remainder of the mission.
25.114(d)(14)(v)(B)	Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity	The satellite will be registered with the 18th Space Control Squadron before satellite acquisition post-separation and initial GPSR TLE tracking data is received.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(v)(C)	The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators	State separation vector and GPS receiver data will be shared with the 18th Space Control Squadron for tracking and space situational awareness.
25.114(d)(14)(vi)	A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks	There are no planned proximity operations.
25.114(d)(14)(vii)	A statement detailing the disposal plans for the space station, including the quantity of fuel - if any - that will be reserved for disposal maneuvers. In addition, the following specific provisions apply	The satellite will be de-orbited at the conclusion of the operational mission using a series of up to five (5) propulsive burns to achieve a targeted Earth atmospheric re-entry over an unpopulated ocean region. 56 kg of fuel will be reserved for the disposal burns to achieve the planned de-orbit. The time from completion of the final de-orbit burn to the beginning of re-entry breakup below 70 km will be less than 30 minutes.
25.114(d)(14)(vii)(A)	For geostationary orbit space stations, the statement must disclose the altitude selected for a disposal orbit and the calculations that are used in deriving the disposal altitude	N/A

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(vii)(B)	For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of through atmospheric re-entry, specifying if direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission	The satellite will be disposed through a targeted atmospheric re-entry and will not be retrieved. The time from completion of the final de-orbit burn to the beginning of re-entry breakup below 70 km will be less than 30 minutes.
25.114(d)(14)(vii)(C)	For space stations not covered by either paragraph (d)(14)(vii)(A) or (B) of this section, the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan	N/A
25.114(d)(14)(vii)(D)	For all space stations under paragraph (d)(14)(vii)(B) or (C) of this section, the following additional specific provisions apply	See below.
25.114(d)(14)(vii)(D)(1)	The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under paragraph (d)(14)(vii)(B) of this section, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under paragraph (d)(14)(vii)(C) of this section, successful disposal will be assessed on a case-by-case basis	The satellite is equipped with high-reliability flight-heritage propulsion and guidance, navigation & control systems capable of successfully performing the above-referenced de-orbit burns at end of life with a 0.94 probability of success assuming a 12-month total mission duration based on demonstrated reliability data.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(vii)(D)(2)	If planned disposal is by atmospheric re-entry, the statement must also include	See below.
25.114(d)(14)(vii)(D)(2)(a)	A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry	Atmospheric re-entry of the satellite will be performed using a controlled targeted re-entry.
25.114(d)(14)(vii)(D)(2)(b)	An assessment as to whether portions of any individual spacecraft will survive atmospheric re-entry and impact the surface of the Earth with a kinetic energy in excess of 15 joules, and demonstration that the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool is less than 0.0001 (1 in 10,000)	Using DAS 3.2.6, 3 of 80 modelled components survive reentry with energies ranging from 137 to 6,458 joules. There is no casualty risk as the satellite will be targeted for direct reentry and disposal to Point Nemo, but if disposal happened outside of Point Nemo, the calculated casualty risk is 1:11,700 exceeding the requirement.
25.114(d)(14)(vii)(E)	Applicants for space stations to be used only for commercial remote sensing may, in lieu of submitting detailed post-mission disposal plans to the Commission, certify that they have submitted such plans to the National Oceanic and Atmospheric Administration for review	N/A
25.114(d)(14)(viii)	For non-U.S.-licensed space stations, the requirement to describe the design and operational strategies to minimize orbital debris risk can be satisfied by demonstrating that debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority	N/A