SES Response to Circular Letter CA/272

1. Introduction

With nearly five decades of experience operating both geostationary orbit ("GEO") and non-geostationary orbit ("NGSO") spacecraft, SES S.A. ("SES") has deep knowledge of, and a unique perspective on, the issues raised in Circular Letter CA/272.[1] SES welcomes the opportunity to provide details on its NGSO disposal strategies.

In addition to its large GEO fleet, SES operates a 26-satellite constellation in medium Earth orbit ("MEO") at an altitude of 8,062 km above the Equator. This orbit is presently unoccupied by other operational systems and is too far above the Earth for atmospheric reentry to be a viable disposal option. SES's post-mission disposal plan is therefore to retire its MEO satellites into a stable graveyard orbit that is away from the orbits of other operational spacecraft, consistent with well-established guidelines. SES believes that high reliability requirements for equipment to be used for disposal, full passivation of stored energy at end-of-life ("EOL"), and maneuverability capabilities during life to reduce risk are vital to ensuring that our satellites are disposed of in a safe and sustainable manner. SES provides the comments herein to elaborate on its post-mission disposal strategy, share information regarding the timing and sequence of its post-mission disposal process, highlight important enabling technologies for post-mission disposal, and provide points-of-contact for further inquiry.

2. MEO Post-Mission Disposal Strategy

When considering NGSO post-mission disposal strategies, it is important to recognize that the Low Earth Orbit ("LEO"), MEO and GEO have different characteristics and present different space sustainability risks. This, in turn, means that different best practices and strategies are appropriate for the different orbits. For example, given the large number of space objects operating in, planned for and launched through the relatively small volume of space at LEO, as well as the feasibility of disposal via atmospheric re-entry, more stringent disposal strategies should be considered for LEO. In contrast, there are far fewer objects occupying a much larger volume of space at the GEO and MEO orbits, which suggests that disposal strategies (such as passivation in a graveyard orbit away from other active satellites) would be more appropriate.

SES has developed its MEO post-mission disposal strategy in accordance with its long-standing commitment to space safety. This commitment is reflected in SES's proven track record of safely operating its spacecraft. Reflecting this sense of responsibility and with the goal of enhancing industry's capabilities in space safety, in 2009, SES joined with several other satellite operators to establish the Space Data Association, an entity dedicated to facilitating the controlled, reliable, and efficient sharing of data that is essential to improving the safety and integrity of satellite

[1] *See* Letter from Mario Maniewicz, Director, International Telecommunication Union ("ITU") Radiocommunication Bureau, to Administrations of Member States and Sector Members of the ITU, Radiocommunication Bureau Circular Letter CA/272 dated 1 March 2024.

operations. In addition, SES joined the Space Safety Coalition, an international organization of satellite operators, government entities, industry representatives, and other key space safety stakeholders, which issued a set of Best Practices for the Sustainability of Space Operations. SES is also an active member of the Global Satellite Operators Association, which has published its own Code of Conduct on Space Sustainability.[2]

Consistent with its demonstrated dedication to space safety, SES has also developed its post-mission disposal strategy in accordance with established international standards. Specifically, as detailed below, SES's MEO constellation EOL disposal plan is designed to ensure compliance with all guidelines set forth in:

- The Inter-Agency Space Debris Coordination Committee (IADC) *Space Debris Mitigation Guidelines,* IADC-02-01 Revision 1, September 2007 Revision 3, 2021;
- ISO 24113:2023 (Space systems – Space debris mitigation requirements), issued by the International Organization for Standardization;
- the post-mission disposal requirements for NGSO space stations adopted by the U.S. Federal Communications Commission, found in *In the Matter of Mitigation of Orbital Debris,* Second Report and Order, *FCC* 04-130, Paragraphs 84-88; and
- all guidance as defined in the *Process for Limiting Orbital Debris* issued by the U.S. National Aeronautical and Space Administration (NASA-STD-8718.14A, §4.6.1(c), 2012).[3]

2.1. End-of-Life Disposal Orbit Design. SES's MEO EOL disposal plan is designed to prevent the re-crossing of the constellation's operational orbit altitude and the crossing of current and future MEO and LEO operational systems including Galileo, GPS and Glonass over a 100-year period. SES has demonstrated the stability of the disposal orbits over 100 years by illustrating the free evolution of the disposal orbit semi-major axis; apogee and perigee; eccentricity; and inclination. For its MEO constellation, SES has also calculated that the disposal orbit will never decay to the LEO range nor approach GEO.

2.2. Contingency Plans. SES has established contingency plans including redundant spacecraft control facilities operating 24/7 should space or ground systems malfunction and for when an emergent situation may necessitate early disposal.

SOC Contingency Plan. SES operates its MEO constellation using two separate satellite operations centers ("SOCs"), one primary and one backup. Each SOC maintains communications with space stations during the deorbit/disposal process. For example, for its O3B mPOWER constellation, SES uses its primary satellite operations center in Manassas, Virginia in the United States, with a backup satellite operations center in Betzdorf, Luxembourg. Both the Manassas and Betzdorf SOCs also have a "cold backup"

[2] GSOA Code of Conduct on Space Sustainability (Nov. 2023), available at https://gsoasatellite.com/wp-content/uploads/GSOA-Code-of-Conduct-Paper.pdf

[3] SES is participating in ESA's Eagle-1 project, which will test a quantum key distribution network over a single LEO satellite. As an ESA project, the satellite must comply with specific safety and de-orbit standards establish by ESA.

SOC which is located within walking/driving distance from the primary SOC and can support satellite operations if something happens to the primary SOC. SES uses these multi-layer redundancies to ensure that operations remain constant.

EOL and Early Disposal. SES's EOL disposal plan allows for post-mission disposal before the anticipated satellite design EOL. The EOL disposal plan provides a plan and process to initiate timely disposal if the spacecraft engineering team determines that a satellite is ready for retirement (*e.g.*, EOL) or no longer performing as intended.

3. MEO Post-Mission Disposal Timetables

3.1. Initiating the Disposal Process. SES plans for post-mission disposal well in advance of any such retirement need. The company closely tracks the satellite health and fuel consumption, updating post-mission disposal plans as appropriate. Further, the disposal process is initiated by a decision of the spacecraft engineering team when the mission of the satellite is approaching its end. Disposal may be the recommended action resulting from any of the following scenarios:

- Any mission-critical component (both primary and redundant units) has become inoperative and, in the judgment of the SES spacecraft engineering team, the satellite is no longer able to safely or adequately provide the service; or
- the amount of remaining propellant has reached the minimum requirement needed for disposal operations; or
- the mission has met its lifetime requirement (*i.e.*, EOL) and the engineering team has decided to stop the operation and dispose of the satellite.

Upon management approval to decommission the spacecraft, the satellite is moved to its disposal orbit in accordance with the terms of its license and following all required notifications to or approvals from the appropriate licensing authorities, and, if necessary, notification to any potentially affected operators.

3.2. End-of-Life Disposal Maneuvers. SES's MEO EOL disposal plan sets forth the procedures used for proper disposal of spacecraft. It describes the maneuvers to be used, the time and energy needed for such maneuvers, and the appropriate steps to be taken to ensure that disposal is coordinated, and collisions avoided. Any payload operations must cease prior to the reorbit/disposal maneuvers.

In its EOL disposal plan, SES provides clear parameters for the reorbit/disposal sequence. The plan allocates enough propellant to include uncertainties. The disposal sequence consists of a spiralling out trajectory in a low-thrust propulsion circular to circular transfer. This sequence has been calculated so that the semi-major axis will increase gradually until reaching the disposal altitude, and inclination and eccentricity will not vary significantly over time.

3.3. Post-Disposal. After the reorbit maneuvers, the flight dynamics system engineers are tasked to determine the success of the operation and confirm that the satellite is in a 'graveyard' orbit. Once verified, each subsystem team will confirm the EOL configurations and certify full decommission of the operation.

4. Enabling Technologies and Maneuverability Capabilities

SES has incorporated the following elements into its EOL disposal plan for its MEO constellations. These items are important for successful post-mission disposal and sustainably maintaining the space ecosystem.

4.1. Reliability Requirements. SES employs high reliability requirements for equipment and technologies to be used for post-mission disposal procedures, in accordance with IADC guidance, to ensure that disposal has a high probability of success. Further, SES plans for and reserves sufficient fuel for EOL maneuvers to achieve the planned disposal orbit. SES anticipates that through advancements in the design and manufacturing of satellite components the disposal of satellites at EOL will also improve.

4.2. Passivation. At EOL of each satellite, SES will perform a passivation procedure to ensure that all stored energy is safely disposed of before the satellite is switched-off in accordance with the EOL disposal plan. This process ensures that propellant is vented; battery charge management is disabled; integrated power control charge rate is terminated; star trackers, inertial reference units, and reaction wheels are powered off; spacecraft control electronics are powered off; telemetry transmitters are disabled; and the payload array sections are commanded off so that the engineering team can safely and completely turn off the satellite. This process can take weeks to complete. Passivation at EOL is important to ensure that no sources of stored energy are available to turn into kinetic energy that could cause the satellite to change orbit, collide with objects, or otherwise become debris after final commands are sent.

4.3. Maneuverability. SES maintains that operators must be able to perform necessary maneuvers to dispose of their spacecraft safely and ensure that collision risk is at a minimum. SES's MEO satellites are all capable of such maneuvering. SES believes that maneuverability is essential to avoid in-orbit collisions and to minimize the risk of creating orbital debris during the active life of the satellite.

5. Points-of-Contact

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