UNITED NATIONS
Office for Outer Space Affairs

Promoting Space Sustainability

Post Mission Disposal of Satellites

ISRO
10 June 2021

Implementation of the Guidelines for the Long-term Sustainability (LTS) of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space

I. Short description of the outer space activity

While pursuing the goals of developingspace technology andapplications for societal benefits, space science and planetary exploration, India has always placed high importance on sustainability of outer space through protection of its space assets and non-proliferation of space debris. India has undertaken various activities pertaining to space debris mitigation, as well as Space Situational Awareness to cope up with the emerging challenges of operating in an exceedingly crowded and contested space domain.

As a member of Inter Agency Space Debris Coordination Committee (IADC), Indian Space Research Organisation has contributed to formulation of recommendations for mitigation guidelines through its participation in IADC meetings, and through Scientific and Technical Subcommittee of UNCOPUOS towards the evolution and development of Space Debris Mitigation Guidelines in the UN. Presently, the guidelines recommended by IADC and UN-COPUOS for space debris mitigation are used by Indian space projects and programmes.

India attached high importance to the safety and sustainability of outer space by carrying out Post Mission Disposal of its GEO space assets to restrict the long-term presence of space objects at the high valued orbits. Presently, all GEO satellites of India carry necessary fuel for post mission disposal to suitable super-synchronous orbit at end of mission.

The lift off timings and the GTO orbits of Indian launch vehicle missions are selected such that the orbital life of the spent upper stages are less than five years. Presently, none of the Indian rocket bodies are in GTO, all havingre-entered the atmosphere within 4 years.

India also strives to improve the compliance with limiting presence of objects in LEO at the end of mission. Towards this, efforts have been initiated to de-orbit LEO satellites at the end of mission wherever feasible. Recent experiences in de-orbiting LEO satellites have garnered invaluable operational experience for ISRO to form a baseline for similar exercises in future.

The post mission disposal of GEO satellites involves a series of orbit manoeuvres.Startingwith the manoeuvres for exiting from the collocated constellation (if applicable) andinitial circularization, alternate apogee and perigee burns are carried out to ensure that the intermediate orbits have low eccentricity. Finallythe perigee raise as per IADC recommendation is achieved,this orbit raise with the final eccentricity lower than 0.003 ensures that the satellite's post mission orbit doesnot decay back to GEO protected region within 100 years. The delta-v required for post mission disposal being typically 10-11 m/s for GEO satellites, the corresponding propellant is reserved in propellant budget at the design phase.

After re-orbiting to disposal orbit, the final passivation burn to fuel depletion is carried out by performing inclination changemanoeuvres instead of changing the semi-major axis to avoid any possible increase in eccentricity.The post mission disposal is followed by electrical passivation, and finally turning off transmitters to avoid radio interference to other GEO satellites.

In 2020, at the end of its mission life, INSAT-4CR was raised to super-synchronous graveyard orbit, and electrically passivated in accordance with IADC recommended post mission disposal guidelines for GEO objects.

In 2020, two LEO satellites, Cartosat-2 and Microsat-TD were deorbited by lowering their perigee altitudes at the end of their operational life to limit post-mission orbital life-time,.Microsat-TD has already re-entered the atmosphere and Cartosat-2 is expected to undergo atmospheric re-entry within 8 years. Cartosat-2 is the first Indian LEO satellite to be deliberately de-orbited to limit its post mission orbital lifetime. This marks an important milestone in the ongoing efforts for space debris mitigation byIndia to comply with LTS guidelines.

II. Connection with the LTS Guidelines

Guideline A.4 Ensure the equitable, rational, and efficient use of the radio frequency spectrum and the various orbital regions used by satellites

[Para 6: Spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the low-Earth orbit (LEO) region should be removed from orbit in a controlled fashion. If this is not possible, they should be disposed of in orbits that avoid their long-term presence in the LEO region. Spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the geosynchronous Earth orbit (GEO) region should be left in orbits that avoid their long-term interference with the GEO region. For space objects in or near the GEO region, the potential for future collisions can be reduced by leaving objects at the end of their mission in an orbit above the GEO region such that they will not interfere with, or return to, the GEO region.The post mission disposal is followed by electrical passivation, and finally turning off transmitters to avoid radio interference to other GEO satellites.]]

Guideline D.2 Investigate and consider new measures to manage the space debris population in the long term.

- investigate the necessity and feasibility of possible new measures and solutions to manage the space debris population
- increase compliance with the Space Debris Mitigation Guidelines

As per LTS guideline A4, India limits the post mission presence of GEO objects to avoid radio interference. As per sub clause 6, India is presently fully compliant with the LTS recommended guideline on post mission disposal for GEO objects. Efforts are underway for better compliance with the guideline on limiting presence of space objects in LEO at end of mission.

As per LTS guideline D.2, the present case studies are the part of efforts taken to increase compliance with the space debris mitigation guidelines.

III. Lessons learned

For GEO satellite,replacement mission needs to be planned to seamlessly retire the satellite at the end of its stipulated life and perform its post mission disposal. Otherwise, extending mission may be inevitable to maintain continuity of service which in turn may result in expenditure of fuel reserved for post mission disposal. Consequently, it may become difficult to achieve the prescribed perigee raise to ensure that the disposed satellite does not encroach GEO region in future, compromising sustainability goals.

Recent disposal exercises of LEO satellites have provided better insights on subtler operational aspects and challenges of disposing of an aging satellite.

This experience will be suitably leveraged in subsequent de-orbiting exercises. It also aided in deriving design requirements to facilitate end-of-life disposal process of future LEO missions, especially regarding fuel allocation for post mission de-orbiting.

For LEO missions operating above 600 km, sufficient fuel needs to be allocated at the design level for post mission de-orbitingto limit orbital lifetime at end of mission for sustainability of LEO.

Extending mission life of a satellite should be based on consideration ofsystem health, fuel availability and redundancy aspects to avoid compromising successful post mission disposal is not compromised.