India’s Efforts in Space Debris Management

Presentation by Indian delegation to 59th session of STSC - UNCOUPOS Vienna, Austria

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India’s space activities aim for societal benefits with long-term sustainability of outer space activity as a key guiding principle.

**Operational spacecraft**
- GEO: 28
- LEO: 21
- Lunar orbiter: 1 (CH2O)
- Mars orbiter: 1 (MOM)

**Non functional objects in orbit**
- PSLV R/B in orbit: 43 (8 decayed, 1 fragmented)
- GSLV R/B: NIL
- Defunct satellites in GEO: 24
- Defunct satellites in LEO: 26
- Decayed satellites: 12
Compliance with Space Debris Mitigation Guidelines

Presently IADC/UN-COPUOS Guidelines on Space Debris Mitigation being followed

Complete compliance with most of the guidelines

Various efforts to comply with the LEO post mission disposal
- All GSLV rocket bodies at GTO have lifetime < 25 years
- Two LEO satellites deorbited minimizing post mission lifetime
- PSLV C38, PSLV C40 upper stages deorbited, re-entered within 1 year

Upper Stage passivation:
- Standard practice for Indian launch vehicles
- Excess fuel in the spent upper stages vented out successfully for all GSLV and PSLV missions.
Conjunction Assessment and Collision Avoidance

Space Object Proximity Analysis (SOPA)

- Regular conjunction analysis with catalogued space objects, re-assessment of CSpOC alerts
- Collision avoidance maneuver (CAM) based on probability threshold
- Screening of routine orbit maneuver plans

<table>
<thead>
<tr>
<th></th>
<th>LEO</th>
<th>GEO</th>
</tr>
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<tbody>
<tr>
<td>Total Number of close approach alerts</td>
<td>4382</td>
<td>3029</td>
</tr>
<tr>
<td>Number of alerts from CSpOC</td>
<td>171</td>
<td>71</td>
</tr>
<tr>
<td>No. of CAMs avoided based on analysis</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>No. of CAMs carried out</td>
<td>14</td>
<td>5</td>
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LV Collision Avoidance Analysis (LCOLA)

- Liftoff clearance of all Indian LV missions
- Conjunction Analysis for ascent/de-boost phase of LV and initial orbits of satellite(s)
- Collision free separation of multiple satellites

Coordination with NASA, SpaceX, NEC (Japan), Hisdesat (Spain), EUMETSAT, ESA, SSTL, OneWeb for risk mitigation
Regular assessment of close approach situation for Mars Orbiter Mission and Chandrayaan-2 Orbiter in close coordination with NASA’s JPL team.

- Close conjunction with NASA’s Lunar Reconnaissance Orbiter (LRO) expected on 20 Oct 2021.
**Post Mission Disposal of Satellites**

### GEO
- Re-orbiting to graveyard orbits above GEO with multiple burns
- Alternating burns at apogee and perigee to ensure circular intermediate orbits
- Post re-orbit passivation
  - Last burn with residual fuel
  - Turning OFF rotating devices
  - Battery discharge
  - Transmitters OFF

**Recently disposed GEO satellites**

<table>
<thead>
<tr>
<th>Name</th>
<th>launch Date</th>
<th>PMD Date</th>
<th>Realised orbital raise (km x km)</th>
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<tbody>
<tr>
<td>INSAT-4A</td>
<td>22-Dec-2005</td>
<td>24-Oct-2019</td>
<td>293 x 288</td>
</tr>
<tr>
<td>INSAT-4CR</td>
<td>02-Sep-2007</td>
<td>05-Nov-2020</td>
<td>301 x 293</td>
</tr>
<tr>
<td>INSAT-4B</td>
<td>12-Mar-2007</td>
<td>24-Jan-2022</td>
<td>388 x 297</td>
</tr>
</tbody>
</table>

### LEO
- **Cartosat-2**
  - At 630 km operational orbit, estimated lifetime more than 30 years
  - Perigee lowered to 380 km by a series of manoeuvres, leftover fuel depleted
  - Post deorbiting estimated lifetime < 5 years

- **Microsat-TD**
  - At end-of-life, de-orbited to deplete leftover fuel and minimise post mission lifetime
  - Atmospheric re-entry within a month, on 27th November, 2020

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**Full Compliance with IADC/UN Guidelines**
Space Object Tracking and Analysis

Multi Object Tracking Radar (MOTR)
- L-band Phased Array Radar at Sriharikota
  - Tracking capability: 50 cm dimension object at 800 km range
  - Successfully tracked larger objects as targets

Optical Telescope
- SPROC (Satellite Photometry Laser Ranging and Optical Communication) Project - two optical telescopes for GEO object observations
  - Tracking capability: 40 cm dimension object at GEO altitude
  - Commissioning expected by 2022

NEtwork for space object TRacking & Analysis (NETRA)
One more telescope and one radar proposed under NETRA

Radar Observation Network for LEO object

Optical Observation Network for GEO object

Control Centre: for processing observational data, analyzing space situation and disseminating SSA information.

SSA Control Centre established at Bengaluru
Modelling Related Activities

Re-entry prediction and aerothermal break-up studies

- Participation in IADC Re-entry prediction campaigns with inhouse developed s/w tools
- Developed in-house s/w tools for reentry aero-thermal breakup and survivability analysis

Micrometeoroid Orbital Debris impact studies and protection

- MMOD Risk assessment and shielding design for NISAR and Gagangyaan, to be adopted in future spacecraft design

Fragmentation Modelling

- ASSEMBLE Model for Debris fragmentation and Evolution Simulation

Gabbard diagram for break-up simulated by ASSEMBLE model
Large Constellations’ Impact on Collision Risk

- Orbital overlap with Starlink
  - Several conjunctions within 1 km, especially for spacecraft at 550 km orbit
  - More frequent conjunctions predicted with proliferation of large constellations

- Migration from 550 km shell
  - Indian Satellites originally slated for 550 km relocated to 574 km.
  - Even after migration, conjunctions observed

- Impact on launch COLA
  - Increase in number of blackouts within launch window

Future concerns

- Considerable Increase in collision probability
- Constraints on safe liftoff time selection
- Imperativeness of extensive coordination with operators
- Observational difficulties due to LEO constellation satellites streaks.
International Collaboration

- Inter agency Space debris Coordination Committee (IADC)
  - Representation in all working groups and Steering Group
  - Participation in re-entry prediction campaign

- Participation in space debris related deliberations in ISO working Group-7, IAA Working Group on Space Debris and STM

- Initiating Collaboration with Space Agencies (DLR, JAXA, ASA, ESA, CNES) for joint efforts on space debris mitigation & Remediation, hosting of joint facilities for space debris observation

- Purchase/Sharing of Space Object Tracking Data from National/ Private SSA agencies for more accurate conjunction analysis

- Training/Workshops
  - 4-day space debris training to ISRO officials by ESA
  - 2-day ISRO-CNES joint workshop on SSA
In a nutshell, India’s efforts focus on:

- Safeguarding of Indian space assets and containing proliferation of space debris.
- Compliance with the IADC and UN space debris mitigation guidelines.
- Establishment of dedicated observational facilities (RADARS, Optical Telescopes, space based platforms) to derive more accurate orbital information of space objects.
- Coordination with national and international bodies to avoid on-orbit collisions.
- Assessment of the orbital debris environment to meet LTS goals.
- Engagement with the emergent Indian space actors to raise awareness on importance of space debris mitigation for long-term sustainability of space activity.