India’s Efforts in Space Debris Management

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Dr. A. K. Anilkumar

Introduction

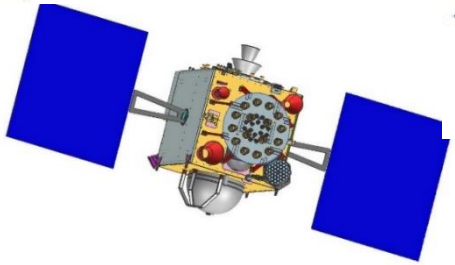
India's space activities aim for societal benefits with long-term sustainability of outer space activity as a key guiding principle

PSLV

GSLV-MkII

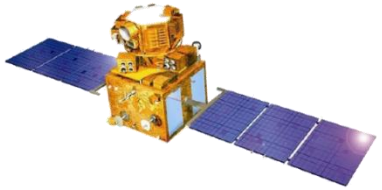
GSLV-MkIII

Communication Satellites



Navigational Satellites

Earth Observation Satellites



Spacecraft for Planetary Missions

Operational spacecraft

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

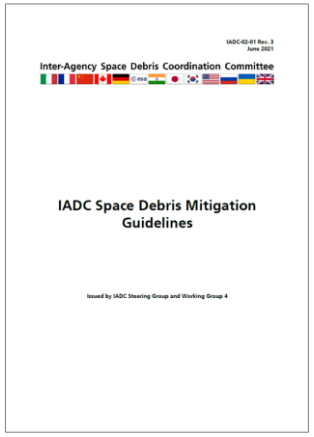
Non functional objects in orbit

- 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:

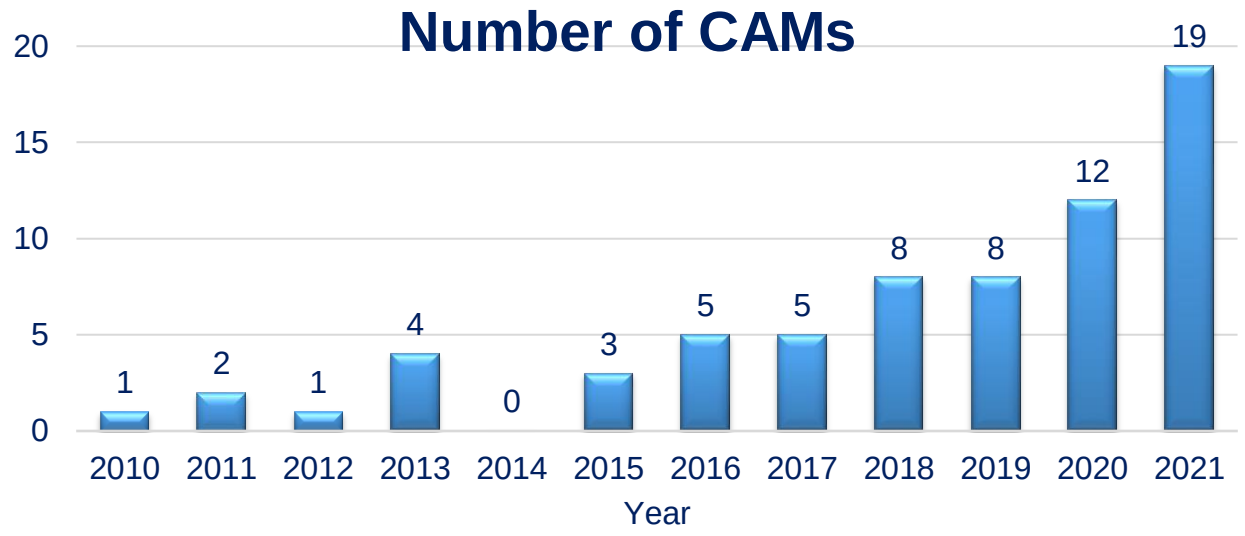
- Standard practice for Indian launch vehicles
- Excess fuel in the spent upper stages vented out successfully for all GSLV and PSLV missions.

Conjunction Assessment and Collision Avoidance

Space Object Proximity Analysis (SOPA)

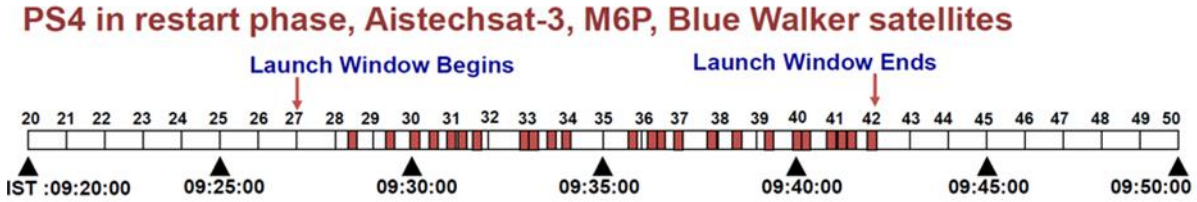
- Regular conjunction analysis with catalogued space objects, re-assessment of CSpOC alerts
- Collision avoidance maneuver (CAM) based on probability threshold
- Screening of routine orbit maneuver plans

	LEO	GEO
Total Number of close approach alerts	4382	3029
Number of alerts from CSpOC	171	71
No. of CAMs avoided based on analysis	6	2
No. of CAMs carried out	14	5



LV Collision Avoidace Analysis (LCOLA)

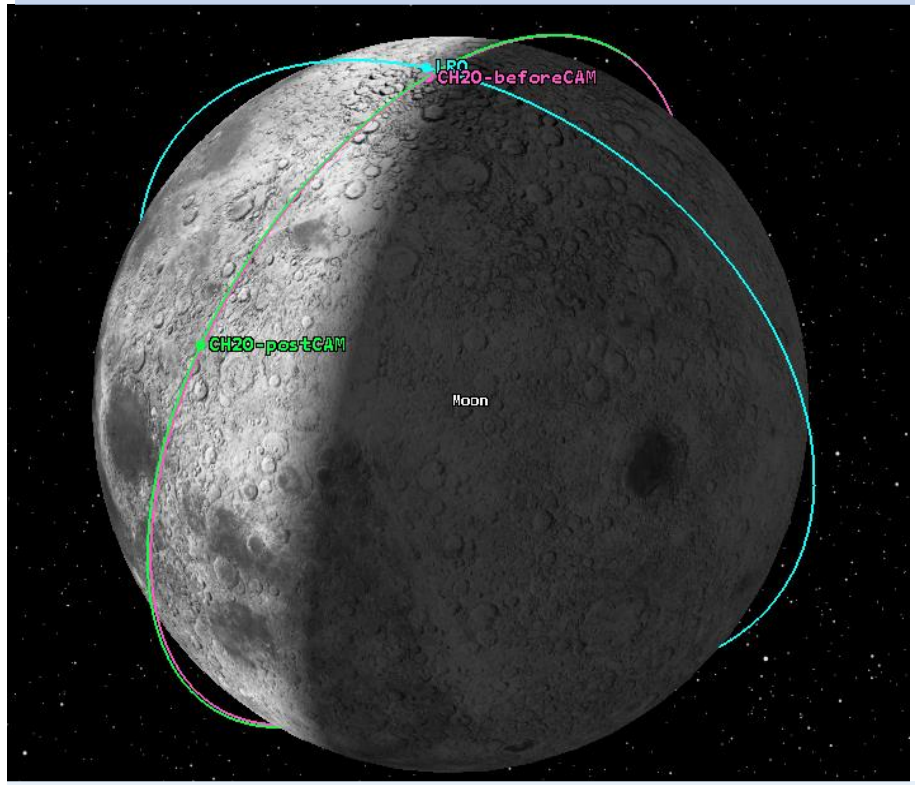
- Liftoff clearance of all Indian LV missions
- Conjunction Analysis for ascent/ de-boost phase of LV and initial orbits of satellite(s)
- Collision free separation of multiple satellites

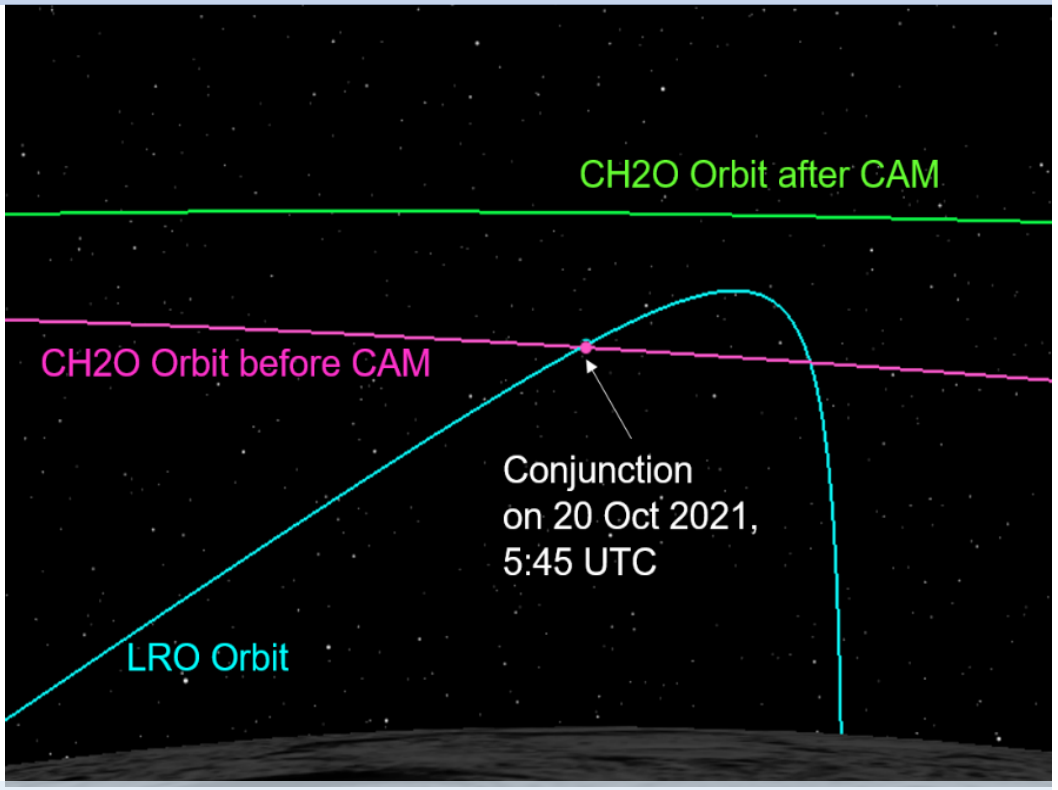


Coordination with NASA, SpaceX, NEC (Japan), Hisdesat (Spain), EUMETSAT, ESA, SSTL, OneWeb for risk mitigation

Chandrayaan-2's Collision Avoidance Maneuver

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.
- Mitigation strategy finalized after deliberations between NASA and ISRO, Chandrayaan-2 maneuvered on 18 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

Full Compliance with IADC /UN Guidelines

Recently disposed GEO satellites

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

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 left over fuel and minimise post mission lifetime
  - Atmospheric re-entry within a month, on 27th November, 2020

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

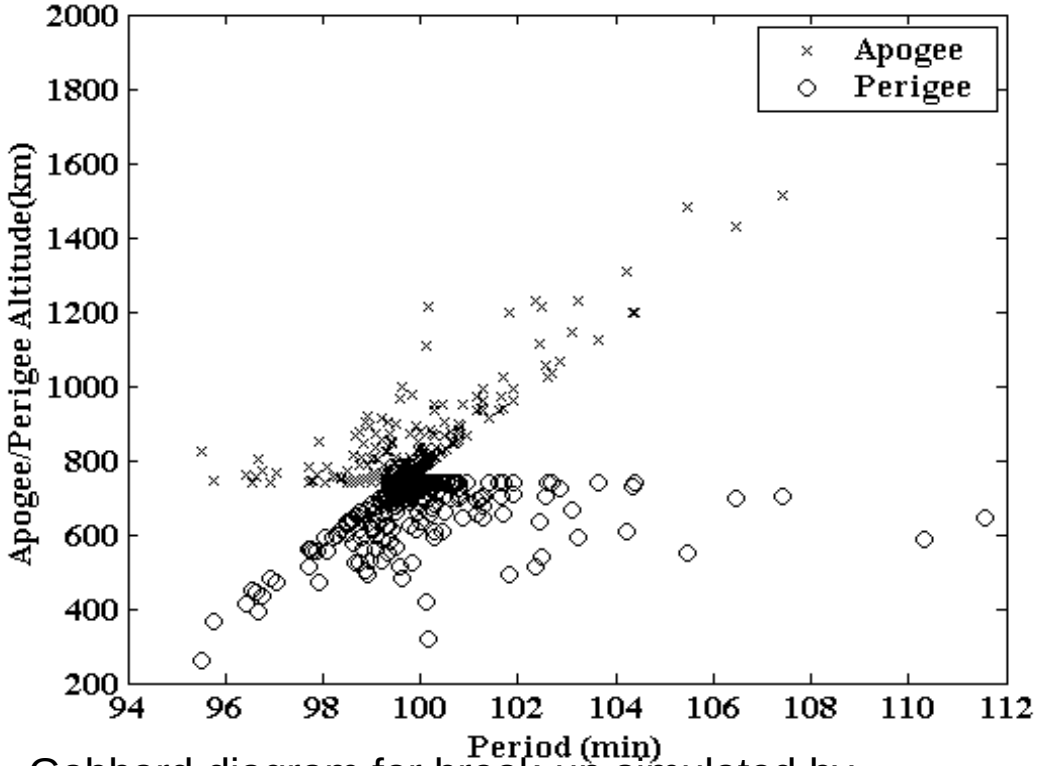
- Participation in IADC Re-entry prediction campaigns with inhouse developed s/w tools
- Developed in-house s/w tools for reentry aero-thermal breakup and survivability analysis

Micrometeroid 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

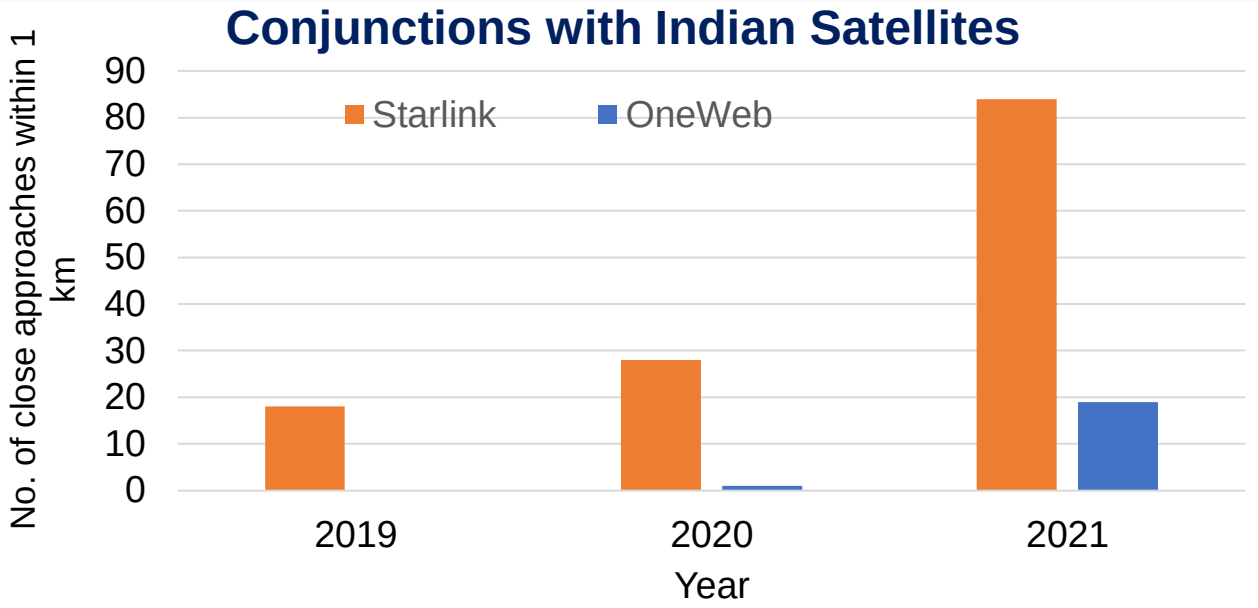
- ASSEMBLE Model for Debris fragmentation and Evolution Simulation



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.

Thank You