Indian Presentation to the 47th Session of Scientific and Technical Subcommittee of United Nations Committee on the Peaceful Uses of Outer Space

Agenda 8

Space Debris Activities in India
Space Debris Activities in India

- Upper Stage Passivation
- Collision Avoidance Analysis
- Space Object Reentry Estimation
- Space Debris Modelling
- Long Term Evolution of Space Debris
- Long-term Sustainability of Outer Space Activities

28th IADC Meeting Hosted by India in March 2010
Upper Stage Passivation: Standard Practice now in All ISRO Launches.

Passivation Successfully accomplished in PSLV-C12 and PSLV-C14 launches on 20th April 2009 and 23rd September 2009 respectively

Passivation Scheme
Venting the pressurant gas from the propellant tank and gas bottles along with the propellant vapors in the tanks. 2 sets of vent nozzles positioned 180° apart. Introduction of separate pyro valve in the pressurization circuit of MMH & MON-3.
PSLV-C14/OceanSat-2 Mission
COLlision Avoidance (COLA) Analysis
Launch Date: 23rd September 2009
Time Segments Not Cleared for Lift Off during the Launch Window 11:51 IST to 12:06 IST

Launch Window Starts
97051PH (0.5 km)
05024D (0.1 km)
93036RQ (0.6 km)
Launch Window Ends
93036RQ (0.4 km)

IST UTC
11:45:00 06:15:00
11:50:00 06:20:00
11:55:00 06:25:00
12:00:00 06:30:00
12:05:00 06:35:00
12:10:00 06:40:00
12:15:00 06:45:00

IST UTC
12:15:00 06:45:00
12:20:00 06:50:00
12:25:00 06:55:00
12:30:00 07:00:00
12:35:00 07:05:00
12:40:00 07:10:00
12:45:00 07:15:00

Lift Off not Recommended in Time Intervals Marked
Maximum (Worst Case) Collision Probability Estimated to be More than 1 in 1,000,000 for PSLV-C14 (in ascent Phase) and 1 in 100,000 (Till the completion of first orbit after Injection) for OceanSat-2
Space Object Proximity Awareness (SOPA) Methodology

Spacecraft Data  →  Resident Space Object Data

Propagation of Spacecraft & Resident Space Object

Close-Conjunction Report
Is generated by filtering conjunctions with min dist ≤ 1 km and/or repeated conjunctions and hence identify the risk objects

Collision Probability Computation

\[ d_{\text{min}} < 100 \text{m} \quad \& \quad P_{\text{col}} \geq 10^{-3} \]

Yes  →  Maneuver Strategy
No  →  Alert issued

Object Size

Space Object Proximity Awareness Analysis is performed on a daily basis.

According to SOPA protocol, if the maximum collision probability exceeds 1 in 1000 or the minimum conjunction distance falls below 100 m, collision avoidance maneuver is performed.

Last year, in one instance, one of the Indian LEO satellites is maneuvered for collision avoidance and for subsequent orbital relocation.
Considering the predictions during the entire campaign and during the final phases of reentry, the performance of the Indian Space Research Organisation in predicting the reentry epoch is among the best.

ISRO Participated in the
IADC RE-ENTRY TEST CAMPAIGN NO. 11
MOLNIYA 3-39 Re-entry campaign:
19 June 2009 to 08 July 2009

Re-entry of GSLV F04 upper stage

Expected Reentry: Dec 2010-Jan 2011
Space Debris Modeling

靥 Modeled Statistically the Semi Major Axis, Eccentricity and Inclinations.

靥 Inclination for objects in Operational GEO belt follows Two Parameter Weibull Distribution Model.

靥 Semi Major Axis modeled using mixture of Laplace Distribution functions – 3 location parameters m1, m2, m3; 3 scale parameters s1, s2, s3; weight parameters p1, p2

\[
f(x) = p_2 \left( \frac{p_1}{2s_1} \exp \left( -\frac{x - m_1}{s_1} \right) + (1-p_1) \exp \left( -\frac{x - m_2}{s_2} \right) \right) + \frac{(1-p_2)}{2s_3} \exp \left( -\frac{x - m_3}{s_3} \right). \]

靥 Log (eccentricity) follows the binary mixture of Normal distributions
Equivalent Fragment Concept for Long Term Evolution of Space Debris Objects Studies

Concept of Equivalent Fragment

(i) Objects are binned in 3 dimensional bands considering semi major axis, eccentricity and ballistic coefficient. It is assumed that each band has a parent body (Equivalent Fragment), which can generate the objects in the band as fragments.

(ii) Equivalent Fragment characteristics are generated based on statistical average for orbital parameters $a, i, \omega, \Omega$. For $e$ and $B$, logarithmic mean are considered.

(iii) Long period orbit propagation analysis is performed for Equivalent Fragments.

(iv) Equivalent Fragments are exploded by a validated procedure back to get objects’ characteristics.

(v) These orbital characteristics are used in assessing the number of objects decayed at the end of the year.
During the last two years India has contributed as a participant in the Informal Working Group on Long Term Sustainability of Space Activities.

One of the major aspect in this context is the growing population of space debris.

India has contributed significantly as an active member in the formulation of the IADC Space Debris Mitigation Guidelines, which eventually led to the adoption of UN COPUOS Space Debris Mitigation Guidelines in 2007, endorsed by UNGA Resolution 62/217 of 21 Dec. 2007.

During the current 47th session, the Scientific and Technical Subcommittee of COPUOS will commence a multi-year work plan on the topic of long-term sustainability of outer space activities. India strongly supports this initiative.
Long Period Orbit Propagation

- Orbit propagator model for eccentricity < 0.2
  - Non-singular, Fourth order analytical solution with air drag effects using Uniformly regular K-S Canonical Variables
  - Earth oblateness
  - Jacchia 1977 density model*

- Results to be used for IADC studies on long term stability of space debris
Indian Space Research Organisation
Welcomes the IADC Member Agencies to the
28th IADC Meeting, March 09-12, 2010
Thiruvananthapuram, India

Inter-Agency Space Debris Coordination Committee
Thank You