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

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Upper Stage Passivation

Collision Avoidance Analysis

Space Object Reentry Estimation

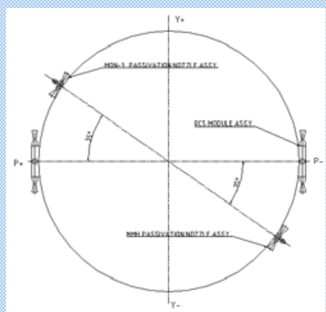
Space Debris Modelling

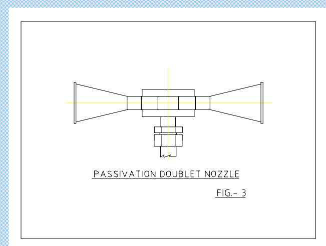
Long Term Evolution of Space Debris

Long-term Sustainability of Outer Space Activities

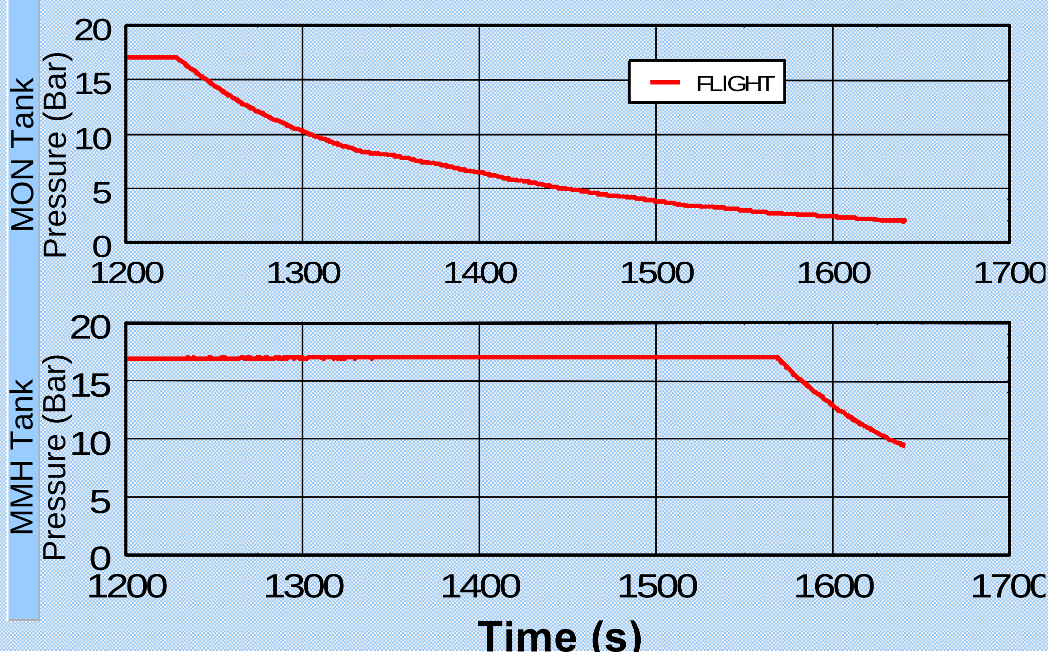
28th IADC Meeting Hosted by India in March 2010

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

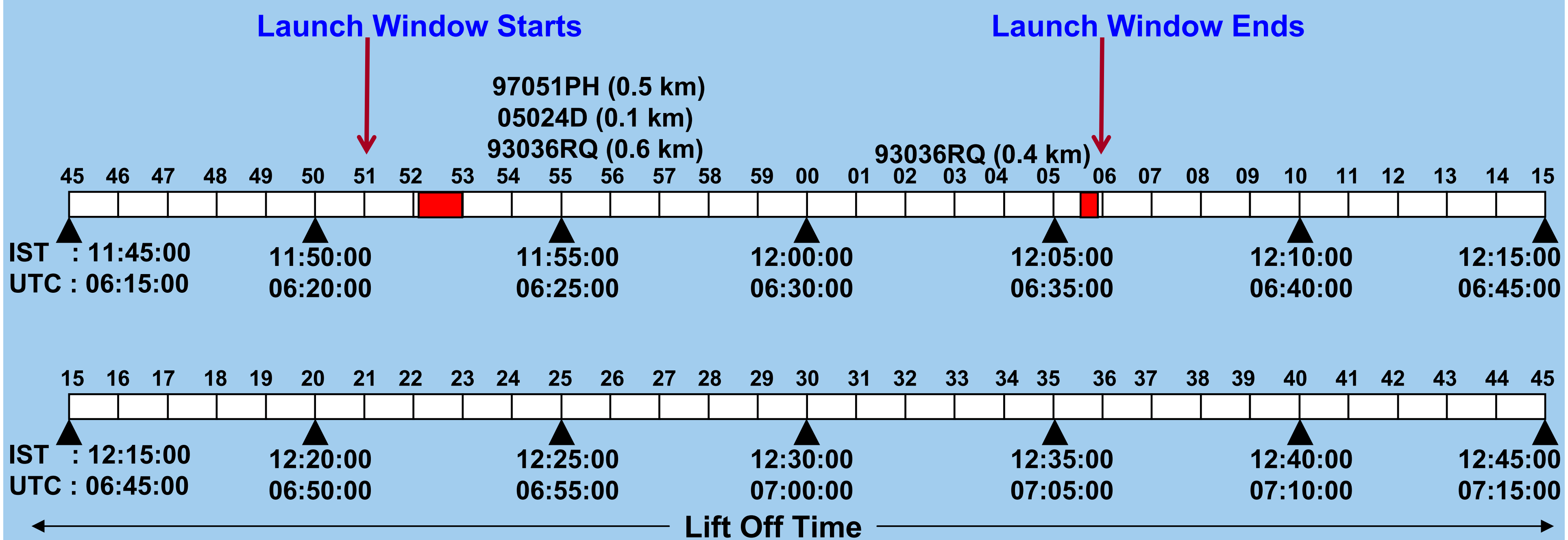
Venting the pressurant gas from the propellant tank and gas bottles along with the propellant vapors in the tanks. 2 sets of vent nozzles positioned 180° apart. Introduction of separate pyro valve in the pressurization circuit of MMH & MON-3.

PSLV-C14/OceanSat-2 Mission

COLlision Avoidance (COLA) Analysis

Launch Date : 23rd September 2009

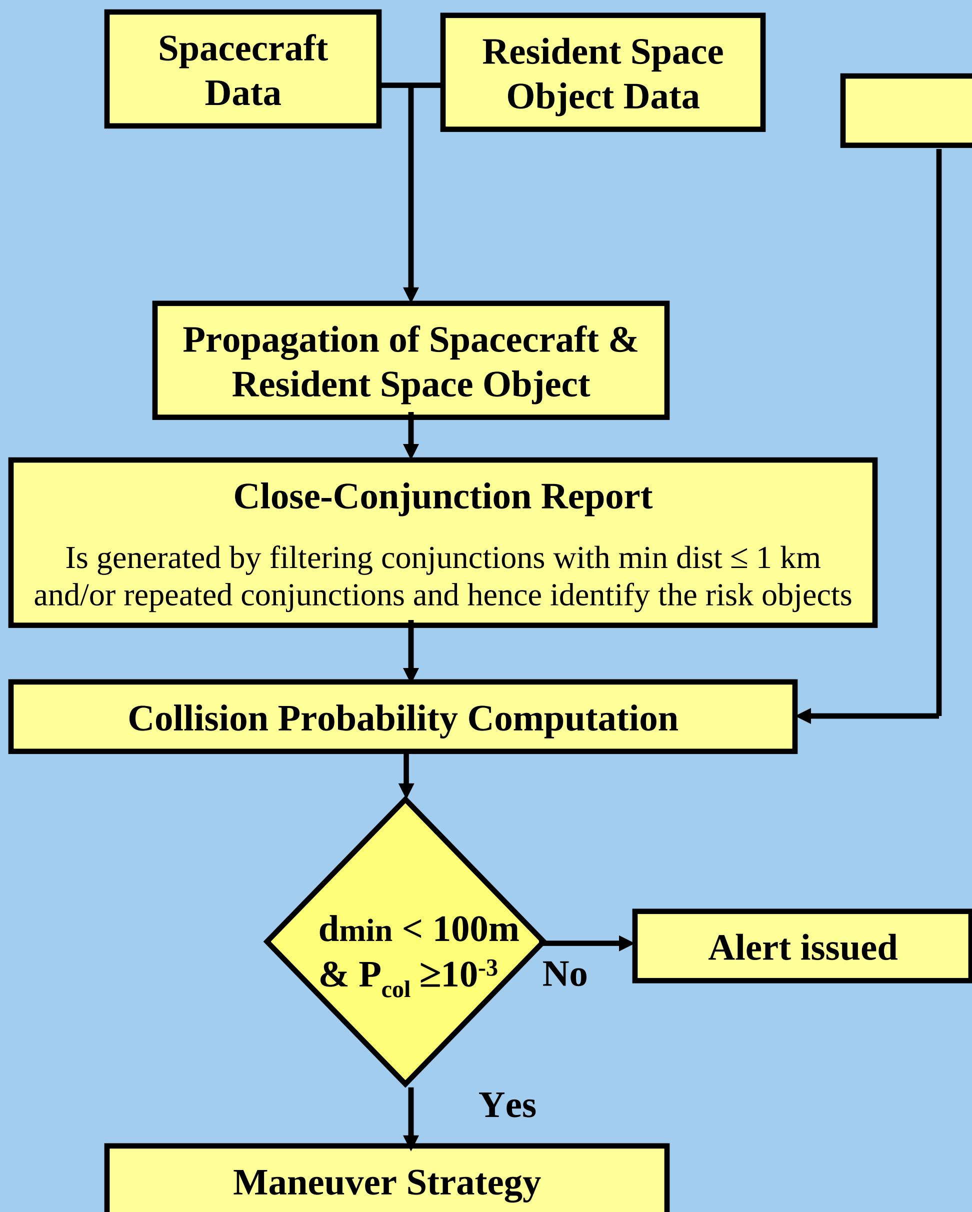
Time Segments Not Cleared for Lift Off during the Launch Window 11:51 IST to 12:06 IST



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



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.

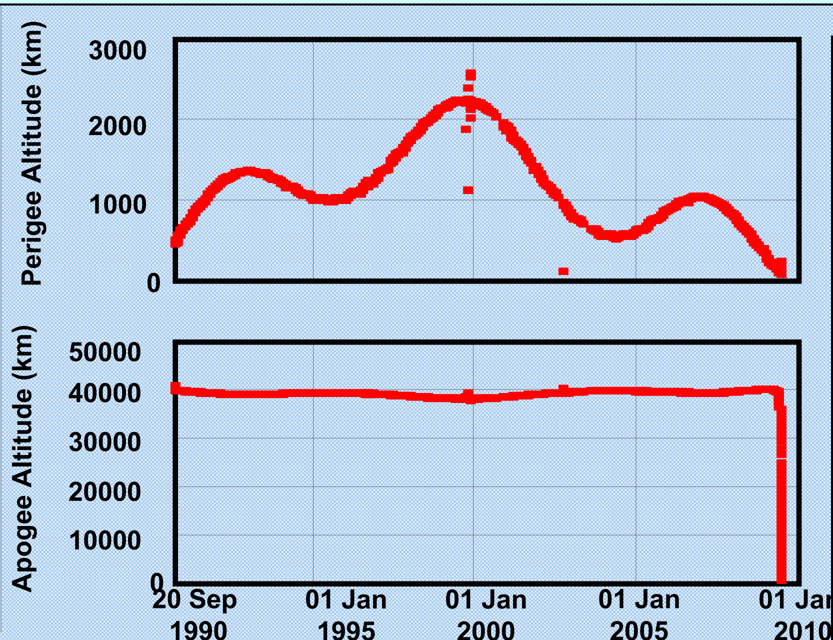
Space Object Reentry Estimation

ISRO Participated in the

IADC RE-ENTRY TEST CAMPAIGN NO. 11

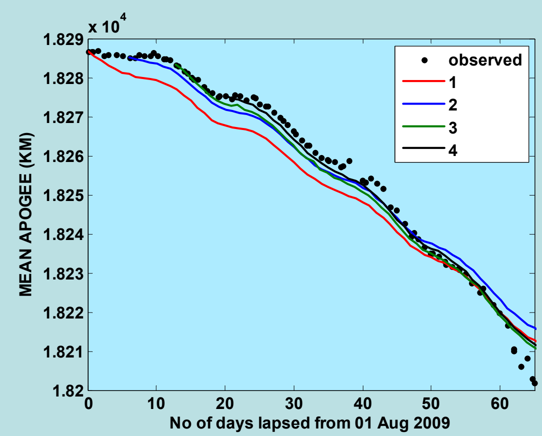
MOLNIYA 3-39 Re-entry campaign:

19 June 2009 to 08 July 2009



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.

Re-entry of GSLV F04 upper stage



Expected Reentry:Dec 2010-Jan 2011

Space Debris Modeling

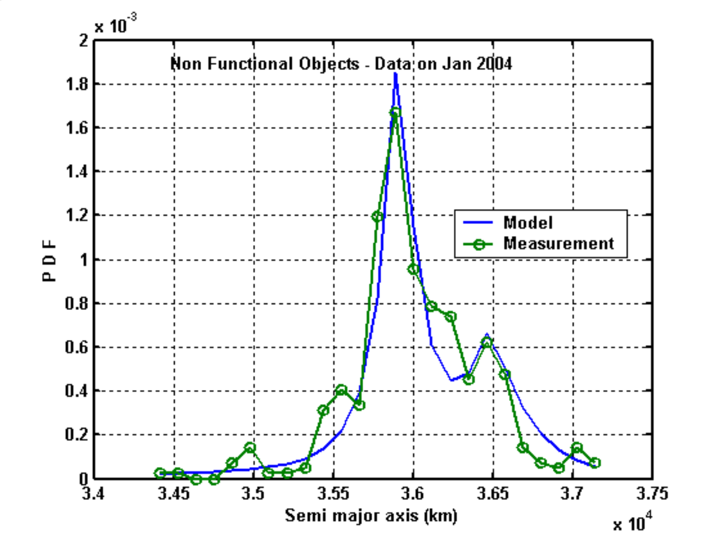
♠Modeled Statistically the Semi Major Axis, Eccentricity and Inclinations.

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

♠ 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

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

♠Log (eccentricity) follows the binary mixture of Normal distributions



The tertiary mixture of Laplace distribution fit for semi major axis of GEO objects

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, ω, Ω. 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.

Long-term Sustainability of Outer Space Activities

During the last two years India has contributed as a participant in the Informal Working Group on Long Term Sustainability of Space Activities.

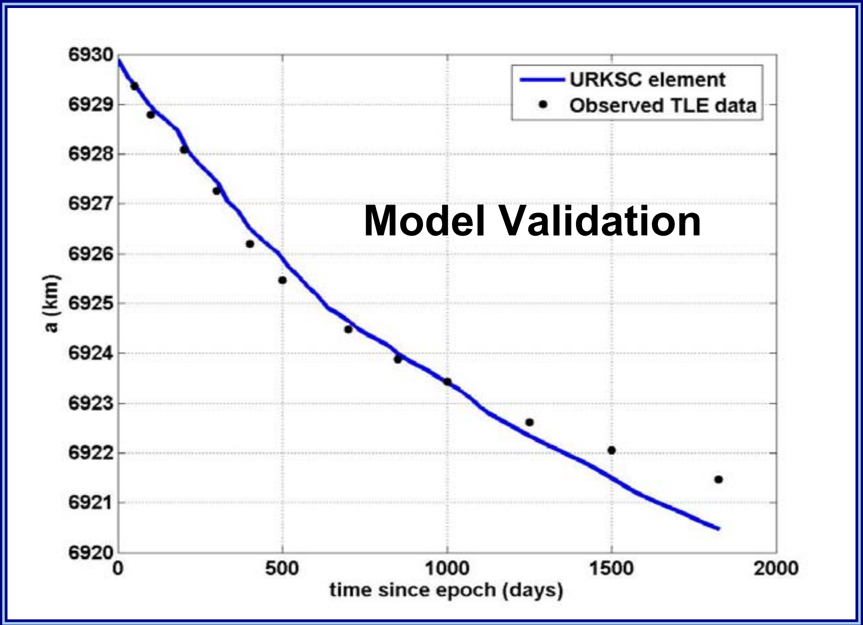
One of the major aspect in this context is the growing population of space debris.

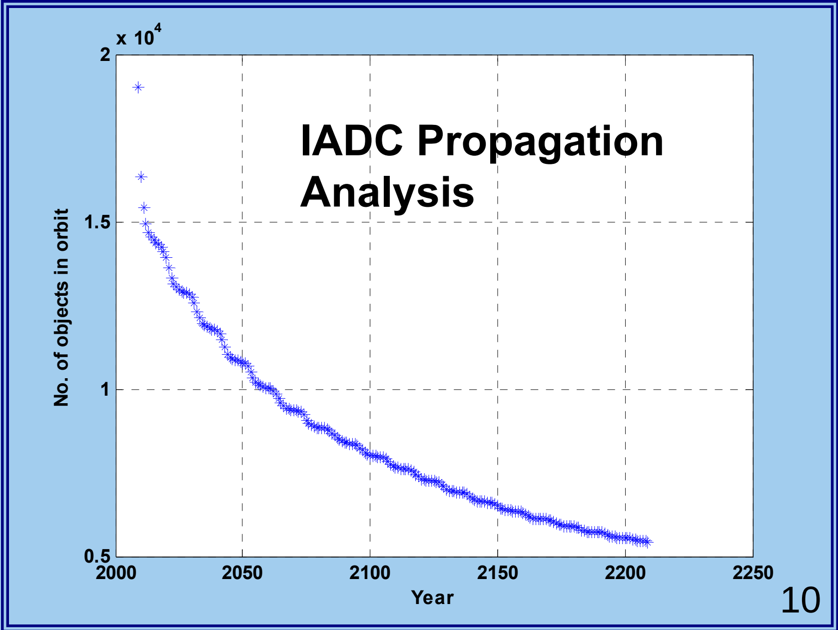
India has contributed significantly as an active member in the in the formulation of the IADC Space Debris Mitigation Guidelines, which eventually led to the adoption of UN COPUOS Space Debris Mitigation Guidelines in 2007, endorsed by UNGA Resolution 62/217 of 21 Dec. 2007.

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, Forth 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