



Indian Space Situational Assessment Report (ISSAR) for 2023 Released

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Shri S. Somanath, Secretary, DOS/Chairman, ISRO, released the Indian Space Situational Assessment Report (ISSAR) for 2023 compiled by ISRO System for Safe and Sustainable Space Operations Management (IS4OM) on April 2, 2024.



Space Situational Assessment 2023

Space assets operating in outer space are vulnerable to various environmental hazards-natural objects like asteroids, comets, and meteoroids, energy and particle flux, and artificial space objects. Therefore, continual awareness of the space environment and its future evolution, namely Space Situational Awareness (SSA), becomes an essential pre-requisite for safe and sustainable operations in outer space. ISRO's SSA activities include close approach assessment of satellites and launch vehicles, prediction of atmospheric re-entry, the study of the evolution of space object population to safeguard national space assets, and also promoting responsible behaviour while conducting operations in outer



space. An annual assessment of the prevailing space situation is also compiled in the form of the Indian Space Situational Assessment Report (ISSAR) for reference and dissemination to the relevant stakeholders. The highlights of the latest space situational assessment for the year 2023 are presented next.

Global Scenario

- The space object population continued to show a growing trend, indicative of better accessibility to space and the increasingly diverse applications of space technology in day-to-day life.
- During the year [1][2][3], more space objects were placed in orbit compared to the previous year. A total of 3143 objects originating from 212 launches and on-orbit break-up events were added to the space object population in 2023 compared to 2533 objects from 179 launches in 2022.
- There were five major on-orbit break-up events in 2023. Some of these fragments decayed within the same year, resulting in a net addition of 69 fragmented objects to the population of space debris by the end of 2023.

Indian Scenario

- Since the beginning of the Indian space era, a total of 127 Indian satellites, including those from private operators/academic institutions, have been launched till 31st December 2023.
- As of 31 Dec 2023, the number of operational satellites owned by Govt. of India is 22 in LEO (Low Earth Orbit) and 29 in GEO (Geo-synchronous Earth Orbit). In addition, three Indian deep space missions were also active by the end of 2023, namely, Chandrayaan-2 Orbiter, Aditya-L1, and the Propulsion Module of Chandrayaan-3.
- A total of 21 Indian satellites have re-entered the atmosphere till the end of 2023. In the year 2023 alone, 8 Indian satellites have re-entered the atmosphere, among them Megha-tropiques-1 underwent controlled re-entry through an immensely challenging exercise.
- A total of 82 rocket bodies from Indian launches were placed in orbit till 2023. The upper stage of PSLV-C3 underwent an accidental break-up in 2001 and generated

371 debris. While most of these fragments have re-entered the atmosphere, 52 PSLV-C3 debris were still in orbit till the end of 2023. Among the intact Indian upper stages, 35 rocket bodies re-entered the Earth's atmosphere till 2023 end, and 5 such re-entries took place in 2023.

- In the year 2023, all seven launches of ISRO, namely SSLV-D2/EOS7, LVM3-M3/ONEWEB_II, PSLV-C55/ TeLEOS-2, GSLV-F12 NVS-01, LVM3-M4/ Chandrayaan-3, PSLV-C56/ DS-SAR, and PSLV-C57/Aditya L-1, were successful. A total of 5 Indian satellites, 46 foreign satellites, and 8 rocket bodies (including POEM-2) were placed in their intended orbits.

Sl. No.	Mission in 2023	Indian Payloads	
		ISRO/GOI	Private/Academic
1	SSLV-D2/EOS-07	EOS-07	AZAADISA 2
2	LVM3-M3/OneWeb India 2	-	-
3	PSLV-C55/ TeLEOS-2	-	POEM-2 hosted non-separating payloads
4	GSLV-F12 NVS-01	NVS-01	-
5	LVM3-M4/ Chandrayaan-3	Chandrayaan-3	-
6	PSLV-C56/ DS-SAR	-	-

7	PSLV-C57/Aditya L-1	Aditya L-1	-
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Close approach risk mitigation for Indian space assets in 2023

Space Object Proximity Analysis (SOPA) for Satellites

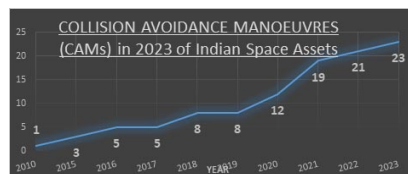
ISRO regularly carries out analyses through IS4OM/ ISTRAC to predict close approaches by other space objects to Indian space assets. In case of any critical close approach, collision avoidance manoeuvres (CAM) are carried out to safeguard the operational spacecraft. The following are the relevant statistics for the year 2023:

- About 137565 close approach alerts were received from USSPACECOM. These alerts were re-assessed using more accurate orbital data of the Indian operational satellites.
- A total of 3033 alerts for the close approaches within a distance of 1 km were detected for ISRO satellites.
- Around 2700 close approaches were observed with other operational satellites within 5 km of close approach distance. On certain occasions, coordination was carried out with other international agencies like SpaceX, EUMETSAT, etc. However, none of the close approaches were critical enough to warrant a CAM.
- The table below consolidates the CAM statistics.

Orbital Regime of Spacecraft	No. of CAMs	Remarks
LEO	18	
GEO	5	Requirements for collision avoidance were incorporated in regular orbit manoeuvres, there were no exclusive CAMs

Total (LEO+ GEO)	23	
Planetary (Chandryaaan-2)	2	To avoid close approach with Lunar Reconnaissance Orbiter (LRO) of NASA and Korea Pathfinder Lunar Orbiter (KPLO) of KARI

The graph shows the total number of collision avoidance Manoeuvres (CAMs) carried out by ISRO for its Earth-orbiting satellites over the last few years. An increasing trend in CAMs per year is observed, which can be correlated with the growing congestion in outer space. No concerning close approaches with other space objects were detected for the Chandrayaan-3 mission throughout its mission phases, and also for Aditya-L1 during its Earth-bound phase. The table shows the number of Orbit Manoeuvres (OM) executed for the ISRO satellites to maintain their orbits within the respective mission-specified limits:



Orbital Regime of Spacecraft	No. of Orbit Manoeuvres (excluding CAM)
LEO	450
GEO	456 (excluding small pulsing manoeuvres)
Planetary (Chandryaaan-2)	17

All manoeuvre plans, including those of the CAMs, were subjected to close approach risk analysis to rule out any potential close approach with other neighbouring space objects imminently after the manoeuvres.

Collision Avoidance Analysis (COLA) for Launch Vehicles

COLA analyses for lift-off clearance of launch vehicles were carried out as part of the mandatory Launch Clearance Protocol of ISRO launch vehicles.

The table below shows the COLA results for the launches in 2023.

	Missiont	Nominal lift-off time (IST)	Delayed by	Launc Pad
1	SSLV-D2/EOS7	10-02-2023 03:48	-	FLP, SHAR
2	LVM3-M3/ONEWEB_II	26-03-2023 03:30	-	SLP, SHAR
3	PSLV-C55/ TeLEOS-2	22-04-2023 14:19	1 min	
4	GSLV-F12 NVS-01	29-05-2023 05:12	-	SLP, SHAR
5	LVM3-M4/ Chandrayaan-3	14-07-2023 14:35:13	4 sec	SLP, SHAR
6	PSLV-C56/ DS-SAR	30-07-2023 06:30	1 min	FLP, SHAR
7	PSLV-C57/Aditya L-1	02-09-2023 06:20	-	SLP, SHAR

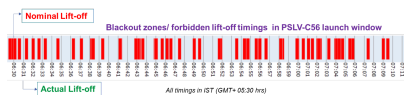
For PSLV-C55/Te-LEOS-2, the nominal lift-off had to be delayed by 1 minute based on the COLA analysis to avoid close approaches between an operational satellite and the injected satellites in their orbital phase due to overlapping operational altitudes.

For LVM3-M4/ Chandrayaan-3, the nominal lift-off had to be delayed by 4 seconds based on COLA analysis to avoid close approaches between a debris object and the injected satellites in their

orbital phase due to overlapping operational altitudes.

For PSLV-C56/ DS-SAR, the nominal lift-off had to be delayed by 1 minute based on COLA analysis to avoid close approaches between Starlink satellites and the injected satellites in their orbital phase due to overlapping operational altitudes.

The figure shows the so-called “black-out” zones within the launch window, over which the lift-off timings were prohibited for the PSLV-C56 launch to avoid potentially close approach risk with other space objects. To resolve close approach situations with active satellites, the required spaceflight safety-related coordination was carried out with the respective operators. Such coordination was also carried out with SpaceX during the PSLV launches.



Spacecraft Decommissioning and Post Mission Disposal

- One of the major highlights of 2023 was the controlled re-entry of Meghatropiques-1 into the Earth's atmosphere over an uninhabited area in the South Pacific Ocean. At its end-of-life, the spacecraft was de-orbited by 20 perigee-lowering manoeuvres, expending about 120 kg of fuel. The final de-boost and re-entry took place on 7 March 2023, which was tracked by ISRO ground station.
- Post injection of the payloads, the upper stage of PSLV-C56 was de-orbited to a nearly circular orbit of 300 km. The rocket body re-entered the atmosphere within 1 month under the influence of drag forces.
- GSAT-12 was decommissioned on March 23, 2023, after being raised to a super synchronous orbit by about 400 km. The disposal orbit was in perfect compliance with IADC-recommended guidelines.
- Decommissioning of IRS-P6 was cleared and final passivation is planned for early 2024. Plans for the passivation of another decommissioned satellite Cartosat-2, due for atmospheric re-entry by Feb 2024, were finalised.

- Chandrayaan-3 propulsion module re-orbited in a lunar escape trajectory and placed in a high Earth orbit having an altitude of more than 2 million km.
- Oceansat-2 was disposed in an orbit at 900 km altitude with a relatively sparse population as the onboard constraints of the ageing spacecraft prevented de-orbiting.

International Cooperation

As a signatory of all major space treaties, India has always placed high importance on the long-term sustainability (LTS) of outer space activities. ISRO System for Safe and Sustainable Operations Management (IS4OM) has been operational since 2022 to safeguard ISRO's space assets and to improve compliance with internationally recognised guidelines on the long-term sustainability of outer space activities.

ISRO is an active participant in many international fora such as the Inter-Agency Debris Coordination Committee (IADC) with 13 space agencies, the International Academy of Astronautics (IAA) space debris working group, International Astronautical Federation (IAF) space traffic management working group, International Organization for Standardization (ISO) space debris working group and UN-COPUOS scientific & technical sub-committee/ legal sub-committee, for discussing space debris issues, related studies and the long-term sustainability of outer space activities. India is the chair of the UN working group on the Long-term Sustainability of outer space activities. ISRO, as the chair of the IADC for 2023-24, will be hosting the 42nd annual IADC meet in April 2024.

ISRO participated in the annual re-entry campaign of IADC with ERS-02 as the test object for the year 2023 and shared the re-entry predictions. ISRO delegation has significantly contributed to the revision of IADC space debris mitigation guidelines, assessment of large constellation effects on space activities, extending space debris mitigation guidelines to cis-lunar region, and other space sustainability aspects of IADC.

Summary and Way Forward

The consolidated data for 2023 indicates a steady growth in the space object population, as reflected

by the maximum number of on-orbit payload deployments with the maximum number of launches in 2023. The number of close approach alerts received and the number of CAMs (Collision Avoidance Manoeuvre) executed by ISRO was also the highest to date.

Operating in an environment inhabited by a growing population of active satellites requires Space Traffic Management (STM). However, unlike air and marine traffic, no universally accepted framework for STM exists at present, hence the resolution of an on-orbit close approach between two active satellites is carried out on case-by-case by inter-operator coordination. With the skyrocketing satellite population, especially in LEO, such coordination will be challenging in the future.

Furthermore, the scope of space-based activities is expanding at a rapid pace with easier access to space with technological advancements, rideshare capabilities, and the growing recognition of the immense potential of space-based technologies, prompting more players to embrace space-based technology and applications. The recent reforms have ushered in a new era for the Indian space sector encouraging more participation from private industries and academia. For sustainable space activities, a holistic approach needs to be taken to catalyse the space sector growth. It must be recognised by all space actors that, unlike terrestrial activities, any activity in space has potentially global and far-reaching implications, and near-Earth space is a finite resource that must be utilized responsibly to harness it for societal benefits.

New ventures like mega constellations, space tourism, human presence beyond Earth etc. present unprecedented challenges to safe and sustainable operations. Addressing these challenges demands innovative solutions with the development of cutting-edge technologies for practical implementation of active debris removal, and on-orbit servicing, in addition to widespread adoption of best practices and guidelines for LTS. Finally, international collaboration plays a pivotal role in ensuring that the near-Earth space environment remains preserved and protected for

the continued exploration and utilisation by our posterity.

References

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