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Inside...

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International Space Station Maneuvers Again to Avoid Debris

The International Space Station (ISS) conducted its first Predetermined Avoidance Maneuver (PDAM) of 2025 to mitigate repeated high-risk conjunctions with a debris object (International Designator 2005-024L, U.S. Satellite Catalog Number 35272). The PDAM took place at 22:10 GMT on 30 April 2025 and raised the altitude of the ISS by approximately 0.53 km. The avoided object appears to be associated with the CZ-2D upper stage (International Designator 2005-024B, U.S. Satellite Catalog Number 28738) that deployed China's SJ-7 spacecraft in 2005. This PDAM increased the total number of collision avoidance maneuvers conducted by the ISS to avoid potential collisions with objects tracked by the U.S. Space Surveillance Network (SSN) to a total of 41 since 1999. ♦

PROJECT REVIEW

An Updated Explosion Rate Methodology for Long-Term Orbital Debris Environment Modeling

A. MANIS, M. MATNEY

On-orbit accidental explosions are a significant contributor to the growth of the orbital debris population, comprising 214 of the 282 historical breakups that occurred as of the end of 2024 [1] (ODQNs: vol. 26, issue 3, September 2022, pp. 2; vol. 27, issue 1, March 2023, pp. 1-2; vol. 27, issue 2, June 2023, pp. 1-2; vol. 27, issue 4, October 2023, pp. 1-2; vol. 28, issue 4, October 2024, pp. 1-2; and vol. 29, issue 1, February 2025, pp. 1). A histogram of historical breakup events by year through 2024 is shown in Figure 1, including all breakup events and only accidental explosions. On average, approximately three explosions per year occurred from 1961 through 2024. In addition, fragments from accidental explosions have historically contributed over half of all cataloged fragments. Due to the historical significance of explosion events, it is important to realistically model their behavior when assessing the future evolution of the orbital debris environment. This project review summarizes a new time-dependent methodology for probabilistically assessing future explosion rates; full details are provided in [2].

NASA's LEO-to-GEO Environment Debris (LEGEND) model is a long-term evolutionary model spanning low Earth orbit (LEO) to geosynchronous orbit (GEO) altitudes. It was developed by the NASA Orbital Debris Program

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Explosion Rate Methodology

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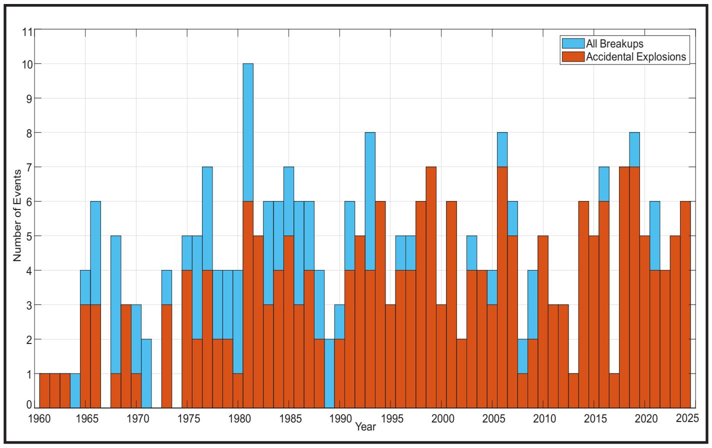

Figure 1. Historical number of yearly breakups from 1961 through 2024 for all breakup events and accidental explosions only.

Office (ODPO) to model the projected future environment based on assumptions of launch traffic rates, postmission disposal (PMD) measures and success rates, remediation measures, solar activity, and probabilistic assessments of explosions and collisions. Explosion probabilities of objects in the future are assessed based on an analysis of historical on-orbit breakup events. A circa 2002 explosion rate model implemented in LEGEND and its predecessor models assigned a probability of explosion based on a type, or family, of either spacecraft (S/C) or rocket bodies (R/B) and applied a constant probability of explosion over a finite time beginning at the object's deployment. The finite time intervals were subdivided in some cases to reflect variations in the historical explosion behavior of specific families of objects. The probabilities were calculated by evaluating the fraction of objects from a particular family that exploded out of the total number of objects in that family for a given interval or intervals of time.

Recently, this methodology was updated to model explosion rates as continuous, time-dependent functions for three broad categories of objects: S/C, R/B, and a specific family of Russian separated Proton 4^{th}-stage attitude and ullage motors called *Sistema Obespecheniya Zapuska* (SOZ) units. The SOZ units are separated as a family because of their significant and unique contribution to historical on-orbit fragmentations [3] and because they have shown a unique temporal behavior of explosions. The continuous, time-dependent methodology was implemented to capture explosion behavior that can vary on significantly different time scales, with some explosions occurring after only a day on orbit – particularly for R/B – to others occurring decades after launch. The analysis presented here uses data on launches and explosions through 2022 taken from the public U.S. Space Surveillance Network (SSN) catalog and confirmed, spontaneous breakup events. For S/C and R/B, only launches and explosions from 1995 through 2022 were considered to account for passivation efforts which were a key element in the orbital debris mitigation guidelines established by NASA in 1995 [4].

In contrast, data for SOZ spanned the entire time period of their use, beginning in 1970. Note that the last cataloged separation of a SOZ from the host R/B occurred in 2012. The number of historical launches and explosions for each category are shown in the table.

Table. Historical launch and explosion data by object category.

Object Category	Years of Consideration	Number of Objects	Number of Explosions
S/C	1995-2022	3129	18
R/B	1995-2022	2093	27
SOZ	1970-2022	380	53

Explosion rates are determined by fitting a continuous function to the historical cumulative number of explosions. The on-orbit lifetime for each object in a category (S/C, R/B, or SOZ unit) is defined as the number of days elapsed from launch date (or separation date, in the case of SOZ units) to either the date of reentry, the date of explosion, or 1 January 2023 if the object was still on orbit at that epoch. The explosion rate is assumed to be governed by a Poisson process. The probability of observing k_i explosions on day i is given by the Poisson equation

$$P(k_i|X_i) = e^{-X_i}\frac{{X_i}^{k_i}}{k_i!} \quad (1)$$

where $X_i = N_i \cdot \Lambda_i$ is the time-dependent expected number of explosions on day i and depends on the number of objects still on orbit that day, N_i, and Λ_i, a time-varying daily probability a single object will explode. Λ_i is assumed to be a function of a parameterized, continuous function $\lambda(t,\vec{\theta})$, which has a different form for each object category (S/C, R/B, or SOZ):

$$\Lambda_i = \int_{t_i}^{t_{i+1}} \lambda(t',\vec{\theta})dt'. \quad (2)$$

A maximum likelihood estimation (MLE) approach is used to determine a best-fit of $\lambda(t,\vec{\theta})$ to the historical cumulative number of explosions as a function of number of days an object is on orbit. The cumulative Poisson probability of a breakup occurring in the time interval $(0, t)$ is then

$$P_C(t) = 1 - e^{-\Lambda(t)}. \quad (3)$$

A total integrated explosion probability P_{tot} for an object category is found by evaluating Equation (3) at a maximum time $t_{max} \to \infty$. Note that this is a maximum theoretical explosion probability that would only apply if all the satellites stayed in orbit and did not decay and reenter for an indefinite length of time.

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Explosion Rate Methodology

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For S/C, the MLE method resulted in a best-fit of a single exponentially decaying probability function with $P_{tot} = 0.044$, so that approximately 4% of the S/C population can be expected to explode assuming infinite lifetimes. The probability function and MLE fit to the historical explosion record are shown in Figure 2. The MLE fit curve is computed by integrating over time the product of the explosion rate $\lambda(t,\vec{\theta})$ and the time-varying number of intact S/C still in orbit for each day.

For R/B, a significant fraction of explosions (8 out of 27, or 30%) occurred within the first day of launch, approximately half (13) occurred within the first 3 days of launch, and the majority (21, or 78%) occurred within 1 year of launch. The best fit to this data was found to be best represented by the sum of three exponential terms corresponding to fast- (λ_{RB1}), medium- (λ_{RB2}), and slow-decaying (λ_{RB3}) components. These are shown in the left panel of Figure 3 on a log-log scale to highlight the different temporal behavior of each exponential term. The fit of the functional form to the historical explosion data is shown in the right panel of Figure 3. The total R/B explosion probability is $P_{tot} = 0.019$.

The historical explosion behavior of SOZ is unique and exhibits a roughly Gaussian behavior with a relatively broad peak around 10-11 years on orbit, which was best represented by a modified Gaussian with a fourth-order exponential term and peak around 3810 days (approximately 10.4 years) on orbit, as shown in Figure 4. This function gives a total explosion probability of $P_{tot} = 0.57$. However, it should be noted that as of 1 January 2023, 27 intact SOZ units remain on orbit, so at most a total of

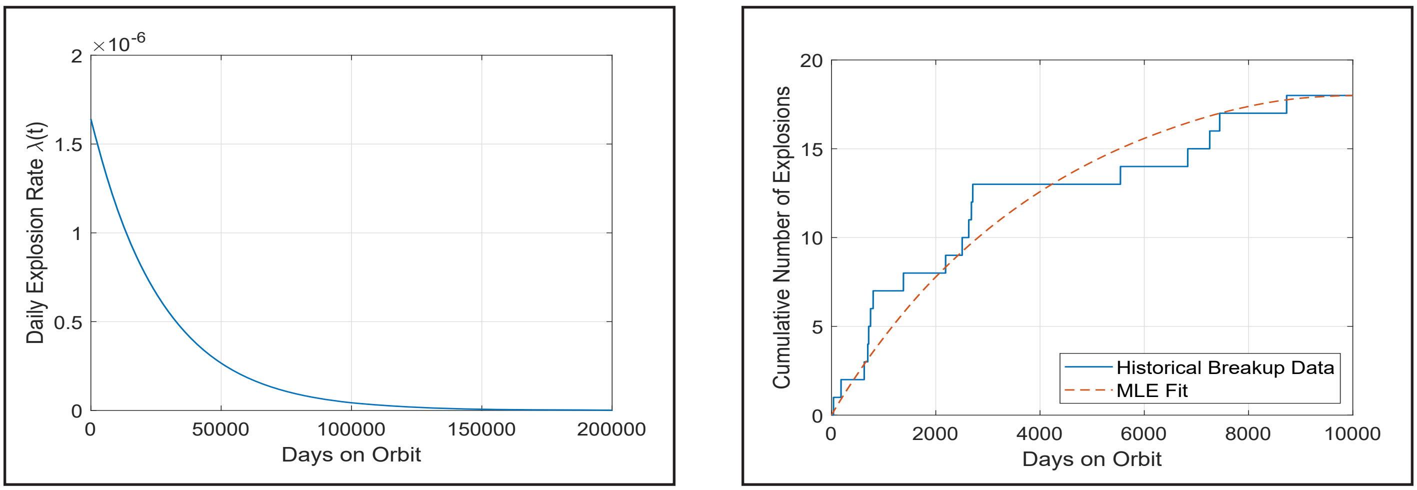

Figure 2. (Left) Probability of explosion by number of days on orbit for S/C. (Right) Cumulative number of S/C explosions, by number of days on orbit, according to the historical data (solid curve) and MLE functional fit (dashed curve).

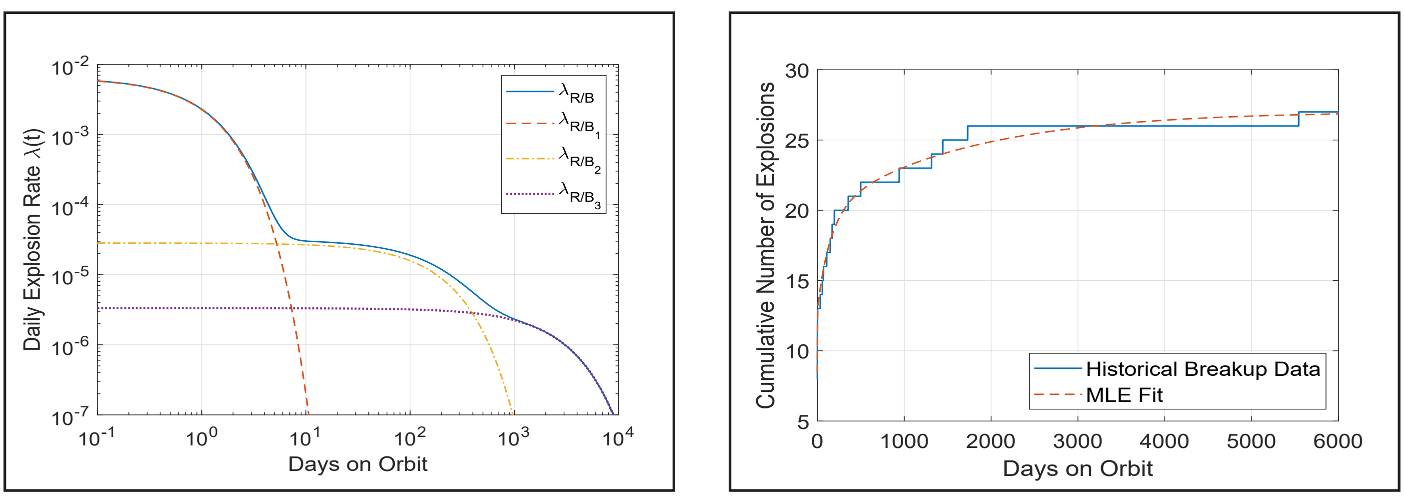

Figure 3. (Left) Probability of explosion by number of days on orbit for R/B, presented on a log-log scale. (Right) Cumulative number of R/B explosions, by number of days on orbit, according to the historical data (solid curve) and MLE functional fit (dashed curve).

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Explosion Rate Methodology

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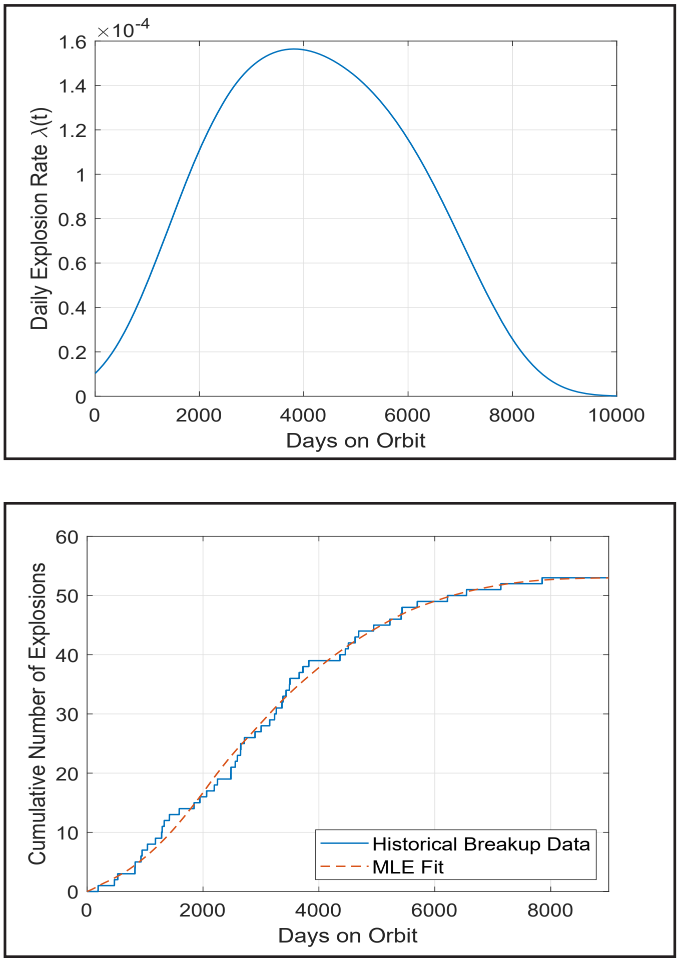

Figure 4. (Top) Probability of explosion by number of days on orbit for SOZ. (Bottom) Cumulative number of SOZ explosions, by number of days on orbit, according to the historical data (solid curve) and MLE functional fit (dashed curve).

80 SOZ units (53 in the past plus the 27 remaining), or 21% of the total, could ever explode.

Implementing this new methodology for a LEGEND 200-year future projection simulation yields an average of 3 explosions per year. This is an increase over the previous explosion model's 1 explosion per year and agrees well with the historical record of explosions. It is important to note that this model does not differentiate between objects that perform PMD and passivate following orbital debris mitigation standards, *e.g.*, the United States Government Orbital Debris Mitigation Standard Practices (ODMSP) [5], and those that do not. This methodology also does not account for different phases of mission operations, which can be difficult to discern in practice. However, analysis of the explosion rates over nominal mission lifetimes can provide some important insights. Assuming a nominal 8-year mission duration for S/C, the integrated explosion probability from Equation (3) over those 8 years is 0.0045, approximately 10% of the total infinite probability of explosion for S/C. Interestingly, the probability of explosion for R/B over a single day is similar at 0.004. Assuming an R/B mission duration of one day, the explosion probabilities for S/C and R/B over their respective mission lifetimes are effectively the same.

These explosion probabilities integrated over a nominal mission lifetime are about a factor of 4 higher than the requirement in the ODMSP, which states that missions should limit the risk of accidental explosion to less than 0.001 (1 in 1000) during deployment and mission operations. The effect of reducing the explosion probability of S/C over an 8-year mission duration from 0.0045 (as determined from the fit to historical data) to 0.001 (as given in the ODMSP) was assessed for a 200-year future LEGEND simulation by scaling the cumulative probability curve from Equation (3). The results are shown in Figure 5 and compare the effective number of LEO objects 10 cm and larger for the two explosion probabilities assuming a no-PMD ("No Mitigation") scenario and a PMD scenario with 90% success rate and 25-year PMD lifetime ("25-year Rule"). Lowering the explosion probabilities reduces the effective number of objects by approximately 21% and 15% for the no-mitigation and 25-year rule scenarios, respectively. Thus, limiting the risk of accidental explosions is a critical component of orbital debris mitigation strategies to limit the future growth of the orbital debris populations and ensure the continued safe use of space.

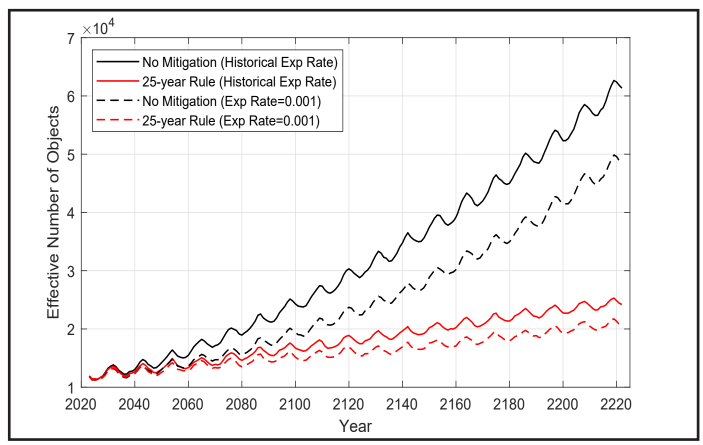

Figure 5. Effective number of objects 10 cm and larger in LEO for the no PMD and 25-year PMD scenarios comparing the default (0.0045) and reduced (0.001) S/C explosion probability over 8-year mission duration.

Activities in space are dynamic and need to be reassessed on a regular basis, especially as launch patterns change, new types of satellites are launched and their explosion behaviors become more evident, additional events occur within the population of long derelict S/C and R/B, and previously undetected explosions of historical objects are identified. Thus, the time-dependent explosion rate model will be reviewed and updated periodically to reflect the ever-changing space environment.

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Explosion Rate Methodology

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2. Manis, A. P., Matney, M. J., Anz-Meador, P. D., and Vavrin, A. B., "Time-Dependent Satellite Explosion Probabilities for Long-Term Orbital Debris Environment Modeling," *Journal of Spacecraft and Rockets*, 2025, DOI: 10.2514/1.A36118.

3. Anz-Meador, P., "Root Cause Classification of Breakup Events 1961-2018," *First International Orbital Debris Conference*, 2019.

4. "NASA Safety Standard: Guidelines and Assessment Procedures for Limiting Orbital Debris," NASA Safety Standard 1740.14, August 1995.

5. "U.S. Government Orbital Debris Mitigation Standard Practices, November 2019 Update," Washington, D.C., 2019. ♦

Overview of the Cataloged Population Over the Past 20 Years

M. MATNEY AND J.-C. LIOU

Since the beginning of the Space Age, keeping track of large objects orbiting Earth has been the responsibility of the Department of Defense with the U.S. Space Surveillance Network (SSN). Tracking satellites in orbit requires sensors capable of accurately measuring their position and velocity. From this state vector, an orbit of sufficient fidelity can be constructed so the object can be uniquely identified and its position can be predicted for a later time at the same or different sensor. Tracking enables the construction of a catalog of objects, where each satellite can be assigned to its launch location, date, and country. For mission-related debris or debris from a fragmentation, the parent object can also be identified. This allows a unique history of each object to be compiled.

Sensors have fundamental limits on the smallest size of objects trackable. Historically, the SSN has had a size limit of ~10 cm in low Earth orbit (LEO), but with the addition of the Space Fence this size limit has been extended to smaller sizes.

By examining the history of these catalogs, it is possible to monitor space traffic and the evolution over time. In this article we will look at the overall distribution of cataloged objects in LEO and identify important trends in the environment over the past 20 years.

For the purposes of this article, the data will be graphed as "number of effective objects per 10 km altitude range." This is a simplified parameter that divides LEO into a series of concentric shells, and each object is counted for the fraction of time spent in each of those altitude shells. This method ignores the inclinations of the orbits, which is an important factor in computing the probability of collision with a satellite as is done in the NASA Orbital Debris Engineering Model (ORDEM).

Figure 1 shows snapshots of the catalog at three reference dates: 2005, 2015, and 2025.

There are dramatic changes over time for different altitudes. By breaking out the catalog by object type (spacecraft, upper stages, and breakup debris), it is possible to explain the changes from 2005 to 2015 and from 2015 to 2025.

Figure 2 shows the altitude distribution of spacecraft. The major changes here are the introduction of CubeSats and large constellations of spacecraft in the environment, especially below 600 km altitude after 2015. The most dramatic changes have been

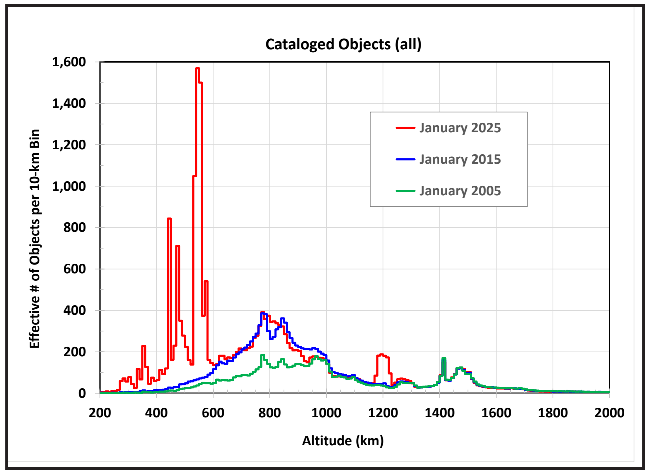

Figure 1. Distributions of the cataloged objects at three different epochs: 2005, 2015, and 2025.

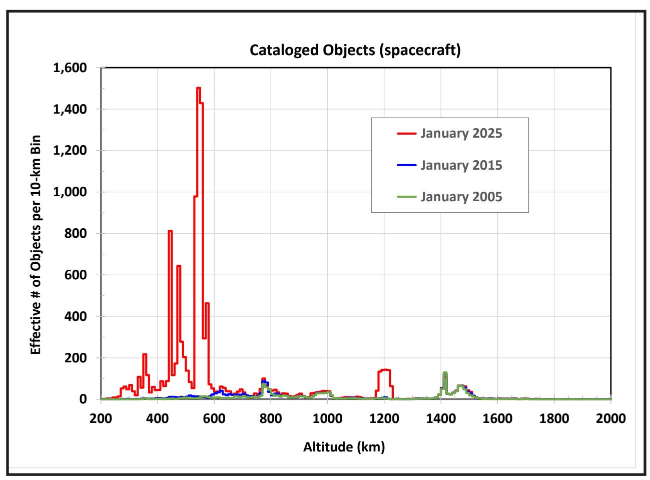

Figure 2. Distributions of the cataloged spacecraft at three different epochs: 2005, 2015, and 2025.

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Cataloged Population

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due to SpaceX's Starlink large constellation spacecraft, mostly operating below 600 km with a peak at 550 km. As can be seen, this number of objects at such low altitudes is unprecedented and it is expected to further increase in the coming months and years. The OneWeb large constellation is responsible for the increase at altitudes around 1200 km, with more than 650 spacecraft currently operating there.

Figure 3 shows the altitude distribution of upper stages – the derelict rocket stages used to place spacecraft in orbit. While there has been some increase in the numbers of rocket bodies left on orbit, the patterns are less dramatic compared to historical patterns.

Figure 4 shows the contributions from breakup debris. This population has major jumps over time due to collisions and explosions in space [1]. Between 2005 and 2015, two major satellite collisions contributed to this debris, specifically the Chinese anti-satellite test that destroyed Fengyun 1-C in 2007 and the accidental collision between the operational Iridium 33 spacecraft and the Cosmos 2251 spacecraft in 2009 (ODQNs: vol. 11, issue 2, April 2007, pp. 2-3; vol. 13, issue 2, April 2009, pp. 1-2). These two collisions alone more than doubled the cataloged objects below 1000 km altitude. Between 2015 and 2025, the Russian anti-satellite test that destroyed Cosmos 1408 in 2021 added more debris (ODQN vol. 26, issue 1, March 2022, pp. 1-5). Since the Russian anti-satellite test was conducted at a relatively low altitude, most of the fragments reentered in several years. In addition, three large explosion events have contributed to the extra debris seen near 800 km in 2025 – the NOAA-16 spacecraft breakup in late 2015 (ODQN vol. 20, issue 1 & 2, April 2016, pp. 1), the CZ-6A rocket body breakup in 2022 (ODQN vol. 27, issue 1, March 2023, pp. 1-2), and the CZ-6A rocket body breakup in 2024 (ODQN vol. 28, issue 4, October 2024, pp. 1-2).

Because hypervelocity collisions in space create so much debris, it is a major factor on the long-term sustainability of the space environment.

While the catalog is useful in tracking what happens in the space environment, the cataloged objects only represent the tip of the iceberg of the orbital debris population. There is a hidden population of smaller debris that is currently untrackable, yet is a major risk for spacecraft operators. So the catalog is an important tool, but it is insufficient to understand the full range of debris risks to safe spacecraft operations. Additional measurement data via radars, telescopes, and *in situ* sensors are needed to characterize the small orbital debris population for the safe operations of future space missions.

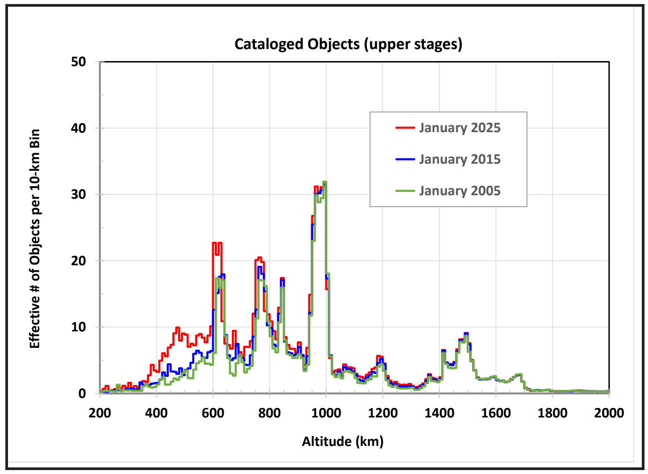

Figure 3. Distributions of the cataloged upper stages at three different epochs: 2005, 2015, and 2025.

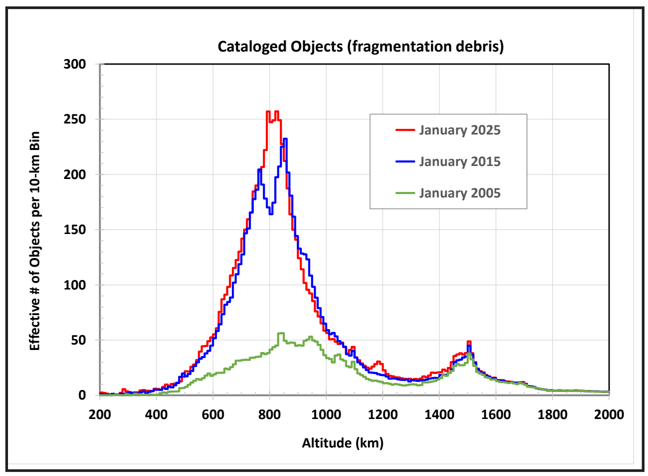

Figure 4. Distributions of the cataloged fragmentation debris at three different epochs: 2005, 2015, and 2025.

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1. Anz-Meador, P. D., Opiela, J. N., and Liou, J.-C., "History of On-Orbit Satellite Fragmentations (16th ed.)," NASA/TP 20220019160, 2022. ♦

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MEETING REPORTS

5-9 May 2025: Applied Space Environments Conference, League City, Texas, USA

The Applied Space Environments Conference (ASEC) 2025 was held 5-9 May 2025 in League City, Texas, sponsored by Space Weather Solutions and organized by the NASA Engineering and Safety Center's (NESC) Space Environments Technical Discipline Team. ASEC is a biennial forum to engage the broader space environments community on characterizing space environments, assessing space environment effects on space systems, and highlighting support for current and future space programs via space environment assessments. Conference participants represented domestic and international organizations from multiple NASA Centers, U.S. Space Force, Japan Aerospace Exploration Agency (JAXA), European Space Agency (ESA), as well as industry and academia. While many of the presentations covered general space environment issues such as radiation, space weather, spacecraft charging, and materials in space, there were several talks on orbital debris, applications for active debris removal, meteoroids, and the lunar ejecta environment. ♦

19-23 May 2025: ISO Standards Working Group Meeting, Tsukuba, Japan

The International Organization for Standardization (ISO) is a non-governmental international organization that publishes standards and related documents enabling trade and cooperation among companies around the world. The spring plenary and working group meetings of the ISO Technical Committee 20 (TC20: Aircraft and Space Vehicles) Subcommittee 14 (SC14: Space Systems and Operations) were hosted by the Society of Japanese Aerospace Companies at the Tsukuba International Congress Center in Tsukuba, Japan, 19-23 May 2025 [1]. The annual plenary meeting brings together all eight working groups of this subcommittee. Subject matter experts from around the world – delegated by their national standards bodies – meet to draft, maintain, and review ISO Standards and supporting documents within the scope of the subcommittee. Work proceeds throughout the year, but face-to-face communication during the annual plenary and semi-annual working group meetings greatly facilitates discussion and understanding. Representatives from NASA's Orbital Debris Program Office join more than two dozen other delegates to SC14 Working Group 7 (WG7: Orbital Debris).

This year's ISO Standards Working Group meeting began with a half-day Opening Plenary Session, discussing high-level business that affects all working groups within SC14. This included items such as harmonization of terminology, SC14 architecture and strategic plan, and liaison reports from organizations outside SC14. After this, the eight working groups separated to work on their tasks, with several joint meetings for overlapping topics, such as between WG3 (Space Operations) and WG7.

This year, WG7 focused on the upcoming fifth edition high-level standard, ISO 24113: Space Debris Mitigation Requirements. Due to accelerating developments in areas such as large constellations and post-mission disposal, WG7 proposed a resolution (to SC14) to begin revising ISO 24113 ahead of its next scheduled review in 2028.

The joint session of WG3 and WG7 included updates and discussion of documents (standards and supporting documents) being drafted or revised within both groups. Topics ranged from large constellations to reentry risk management. Representatives from SC14 Working Group 1 (WG1: Design Engineering and Production) attended a presentation concerning questions about Lithium-ion (Li-ion) battery probability of explosion (*i.e.*, debris-producing event) and end-of-mission passivation, which may fall within the scope of a WG1 standard for Li-ion battery design requirements. The joint session also included liaison reports and the topic of terminology harmonization. Liaison representatives reported on activities of the Inter-Agency Space Debris Coordination Committee (IADC); European Cooperation for Space Standardization (ECSS); International Astronautical Federation (IAF); United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS); United Nations Office for Outer Space Affairs (UNOOSA); and the Consultative Committee for Space Data Systems (CCSDS, associated with ISO SC13: Space Data and Information Transfer Systems). Delegates also heard unofficial updates of debris-related topics within the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) and the International Telecommunication Union (ITU).

While the SC14 Plenary meets once per year, the working groups have both spring and autumn meetings. With the next in-person meeting of WG3 and WG7 scheduled for November in Arlington, VA, delegates continue to work on action items, draft and revise standards and supporting documents, and stay in contact electronically. The main task for WG7 is to collect and debate the many suggested changes to ISO 24113, and from those changes, create a revised orbital debris mitigation standard for industry.

References

1. Subcommittee home page: https://www.iso.org/committee/46614.html. ♦

17 June 2025: The NASA-DOD Orbital Debris Working Group Meeting, Virtual

The 28th annual NASA-DOD Orbital Debris Working Group (ODWG) meeting was held virtually, with teams teleconferencing from Houston, Texas, and Colorado Springs, Colorado, on 17 June 2025. This annual one-day meeting provides the framework for cooperation and collaboration between NASA-DOD on orbital debris-related activities, such as measurements, modeling, mitigation, and policy development. NASA and the DOD have benefited significantly from this meeting, and many collaborations directly result from this WG. The meeting was co-chaired by the NASA Orbital Debris Program Office (ODPO) and by the Operational Assessments Division, HQ Space Operations Command, United States Space Force (USSF).

Meeting Reports

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The USSF and the NASA ODPO provided opening remarks, followed by a series of presentations from members representing NASA and the DOD. The ODPO opened with a presentation on recent updates to the Debris Assessment Software (DAS) and Object Reentry Survival Analysis Tool (ORSAT). Second, the ODPO presented on NASA's recent efforts in establishing a common understanding of the requirements levied on spacecraft designers and operators for battery passivation at the end of mission and methods for verifying compliance. This presentation was succeeded by an update on the DebriSat project and the fusion of measurements and analysis from the project into the next generation NASA Orbital Debris Engineering Model (ORDEM) 4.0 and NASA Standard Satellite Breakup Model (SSBM). Following this, the ODPO presented on Haystack Ultrawideband Satellite Imaging Radar (HUSIR) and Goldstone Orbital Debris Radar observations of the orbital debris environment.

The ODPO also provided an update on the development of the ODPO's in situ debris sensor, Multi-layer Acoustic & Conductive-grid Sensor (MACS), and its upcoming flight demonstration mission. The ODPO presented results of the second survey of the geosynchronous orbit regime conducted by the Eugene Stansbery-Meter Class Autonomous Telescope (ES-MCAT) from 2023-2025. Additionally, the ODPO presented on the recent laboratory optical and radar measurements of representative debris and calibration objects for building and verifying new size estimation models. The final ODPO presentation included updates on the development of ORDEM 4.0.

The DOD personnel presented an overview of the Space Fence on Kwajalein Atoll, the Space Surveillance Telescope in Western Australia, and an overall status of the Space Surveillance Network. The following presentations discussed recent on-orbit breakups and the radar cross-section calculation process conducted by the 18th Space Defense Squadron (18SDS) at Vandenberg Space Force Base. The succeeding DOD presentation focused on efforts in space domain awareness and methods to track and catalog spacecraft in cislunar space. The final presentation explained the DOD process for verifying spacecraft missions' compliance with battery passivation and accidental explosion probability requirements per the U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP). ♦

RECENT OR UPCOMING MEETINGS

10-13 August 2025: 39th Small Satellite Conference, Salt Lake City, Utah, USA

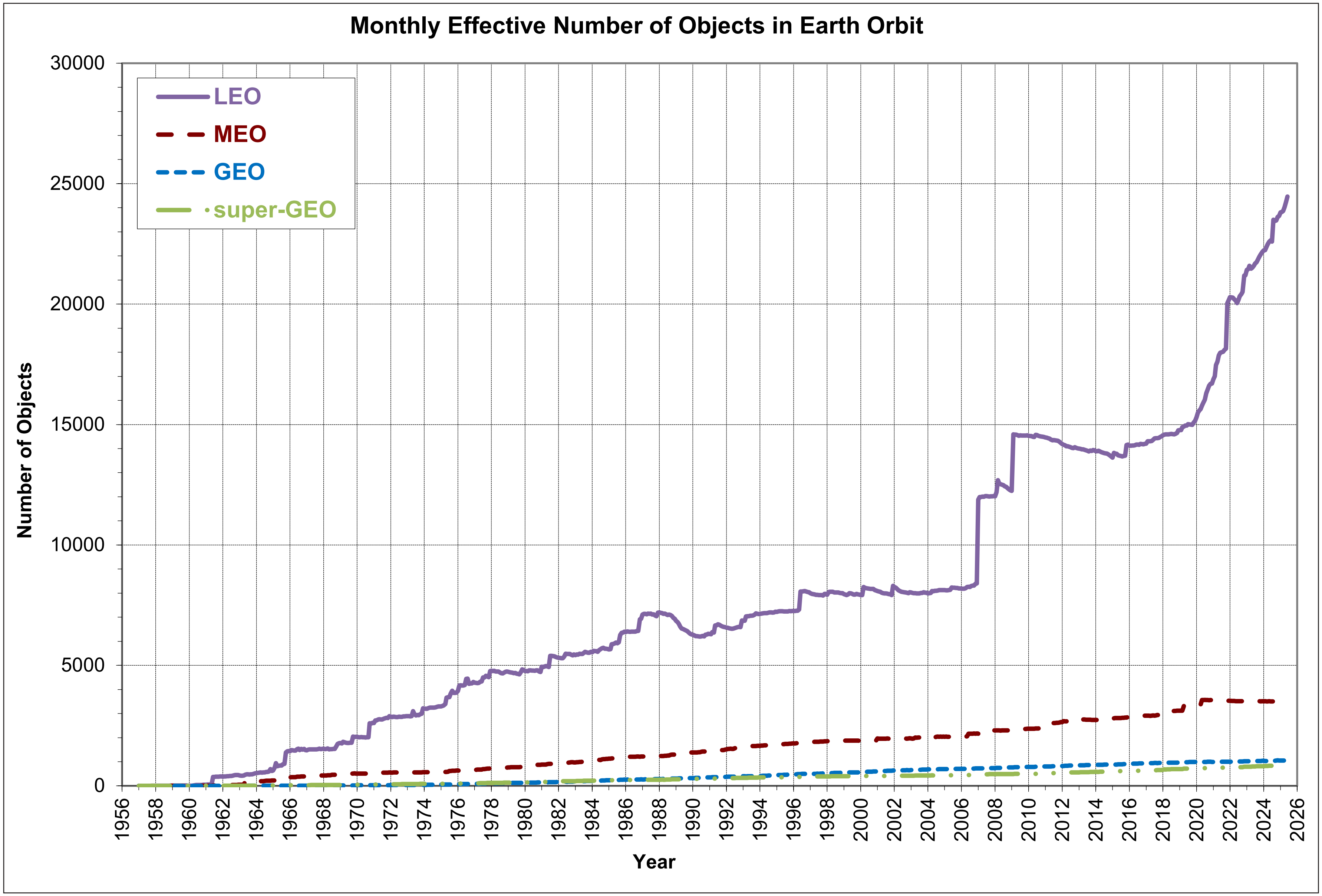
The 39th Small Satellite Conference centered around the theme of "Reaching New Horizons. New orbit. Same Mission." The demand from governmental, commercial, and academic stakeholders to have access to space is made possible through satellite research and technological advancements discussed at this annual meeting. This conference delved into the innovations and collaboration from diverse stakeholders currently shaping the future of satellite capabilities. Conference information is available at https://smallsat.org/. ♦

16-19 September 2025: 26th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS), Maui, Hawaii, USA

The technical program of the 26th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS) will focus on subjects that are mission critical to space situational awareness. The technical sessions include papers and posters on space debris; space situational/space domain awareness (SDA); SDA systems and instrumentation; astrodynamics; satellite characterization; space weather; and related topics. The abstract submission deadline was 3 March 2025. Additional information about the conference is available at https://amostech.com/. ♦

29 September-3 October 2025: 76th International Astronautical Congress (IAC), Sydney, Australia

The 76th International Astronautical Congress (IAC) will be hosted by the Space Industry Association of Australia (SIAA) in Sydney, Australia, with a theme of "Sustainable Space: Resilient Earth," from 29 September to 3 October 2025. The International Academy of Astronautics (IAA) Space Debris Committee will again organize the Space Debris Symposium during the IAC. Ten debris sessions are planned on topics such as debris detection and tracking, environment modeling, mitigation, remediation, sustainability, and policy. The abstract submission deadline was 28 February 2025. Additional details of the 76th IAC are available at: https://www.iac2025.org/. ♦



Monthly Effective Number of Objects in Earth Orbit by Orbital Regime cataloged by the U.S. Space Surveillance Network as 28 July 2025. This chart displays the number of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. Low Earth orbit (LEO) includes resident space objects (RSOs) with altitudes within or crossing below 2,000 km; medium Earth orbit (MEO) RSOs with altitudes within or crossing the range from 2,000 km to 35,586 km; geosynchronous orbit (GEO) RSOs with altitudes within or crossing the range from 35,586 km to 35,986 km; and the remainder with altitudes within or crossing the range from 35,986 km to 600,000 km, referred to as Super-GEO. "Effective" number sums the fraction of each orbit that falls within the specified ranges. Cataloged objects without available orbital elements are excluded.

SATELLITE BOX SCORE

(as of 4 June 2025, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Spacecraft*	Spent Rocket Bodies & Other Cataloged Debris	Total
CIS	1575	5056	6631
ESA	104	26	130
FRANCE	120	519	639
INDIA	112	83	195
JAPAN	201	96	297
PRC	889	4557	5446
UK	717	1	718
USA	9779	4757	14536
OTHER	1158	87	1245
Total	14655	15182	29837

* active and defunct

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Intl. = International; SC = Spacecraft; Alt. = Altitude; Inc. = Inclination; Addl. = Additional; R/B = Rocket Bodies; Cat. = Cataloged

Notes: 1. Orbital elements are as of data cut-off date 30 April. 2. Additional spacecraft on a single launch may have different orbital elements. 3. Additional uncatalogued objects may be associated with a single launch.

INTERNATIONAL SPACE MISSIONS

1 February 2025 – 30 April 2025

Intl.* Designator	Spacecraft	Country/ Organiza-tion	Perigee Alt. (KM)	Apogee Alt.(KM)	Inc. (DEG)	Addl. SC	Earth Orbital R/B	Other Cat. Debris
2025-022A	STARLINK-32868	US	446	448	53.2	21	1	0
2025-023A	QZS-6	JPN	35777	35797	0.1	0	1	0
2025-024A	STARLINK-11371	US	354	359	43.0	20	0	0
2025-025A	LEGION 5	US	699	707	45.05	0	0	0
2025-025B	LEGION 6	US	521	549	45			
2025-026A	COSMOS 2581	CIS	579	594	82	2	2	1
2025-027A	STARLINK-11552	US	355	358	43	20	0	0
2025-028B	KINEIS-2C	FR	651	655	98	4	2	0
2025-029A	STARLINK-32728	US	474	476	53.16	22	0	0
2025-030A	HULIANWANG DIGUI-11	PRC	1149	1149	50	8	1	0
2025-031A	STARLINK-11543	US	354	359	43	20	0	0
2025-032A	STARLINK-11448	US	354	358	43	20	0	0
2025-033B	GLOBAL-31	US	438	466	59	0	2	0
2025-034A	STARLINK-32798	US	474	477	53.16	22	0	0
2025-035A	STARLINK-11550	US	354	359	43	22	0	0
2025-036A	CHINASAT 10R	PRC	35768	35805	0.04	0	1	0
2025-037A	STARLINK-32839	US	567	572	70	21	0	0
2025-038A	IM-2	US	LUNDAR LANDING			0	1	0
2025-038B	CHIMERA-1	US	EN ROUTE TO GEO (VIA LTO)					
2025-038C	LUNAR TRAILBLAZER	US	HELIOCENTRIC					
2025-038D	BROKKER-2 ODIN	US	HELIOCENTRIC					
2025-039A	STARLINK-11629	US	355	358	43	20	0	0
2025-039A	SUPERVIEW NEO-1 03	PRC	500	502	97.32	0	1	0
2025-040B	SUPERVIEW NEO-1 04	PRC	500	502	97.33			
2025-041B	PROGRESS MS-30	CIS	415	417	51.64	0	1	0
2025-042A	COSMOS 2584 (GLONASS)	CIS	19114	19146	64.88	0	1	0
2025-043A	STARLINK-11609	US	355	358	43	20	0	0
2025-044A	CSO-3	FR	NO ELEMS. AVAILABLE			0	0	0
2025-045A	TJS-15	PRC	35772	35800	0.25	0	2	0
2025-046A	QIANFAN-73	PRC	1059	1078	88.98	17	1	0
2025-047A	PUNCH-NFI00	US	641	655	97.95	4	0	1
2025-048A	STARLINK-11602	US	354	358	43	20	0	0
2025-049A	DRAGON ENDURANCE 4	US	415	417	51.64	0	0	0
2025-050A	QPS-SAR-9	JPN	570	574	42.02	0	2	0
2025-051A	OBJECT A	PRC	492	495	97.49	0	0	0
2025-051B	OBJECT B	PRC	477	487	97.48			
2025-052A	JINJUSAT-1B	SKOR	502	505	97.44	65	0	0
2025-053A	STARLINK-11654	US	356	357	43	22	0	0
2025-054A	COSMOS 2585	CIS	1474	1514	82.49	2	0	0
2025-055A	OBJECT A	PRC	528	552	97.61	7	0	0
2025-056A	KINEIS-4E	FR	652	655	97.98	4	2	0
2025-057A	STARLINK-11568	US	355	357	43	22	0	0
2025-058A	USA 487	US	503	517	69.99	10	0	0
2025-059A	YUNYAO-1 43	PRC	533	553	97.6	5	0	0
2025-060A	USA 498	US	1009	1206	63.44	0	0	0
2025-061A	LEMUR 2 UNTITLED-SC	US	522	553	97.52	7	2	0
2025-062A	TIANLIAN-2 04	PRC	35661	35911	5.32	0	1	0
2025-063A	STARLINK-32840	US	446	449	53.16	26	0	0
2025-064A	TJS-16	PRC	35777	35795	0.16	0	1	0
2025-065A	STARLINK-33531	US	443	445	43	27	0	0
2025-066A	FRAM-2	US	345	445	89.68	0	0	0
2025-067A	OBJECT A	PRC	414	425	54.99	3	0	0
2025-068A	TIANPING-3A02	PRC	451	789	43	0	0	0
2025-069A	STARLINK-33682	US	446	448	53.16	26	0	0
2025-070A	STARLINK-33679	US	482	485	43	27	0	0
2025-071A	STARLINK-33828	US	456	456	53.16	26	0	0
2025-072A	SOYUZ MS-27	CIS	415	417	51.64	0	1	1
2025-073A	TJS-17	PRC	35778	35794	0.12	0	2	0
2025-074A	USA 499	US	281	325	69.9	21	0	0
2025-075A	STARLINK-11669	US	335	338	43	20	0	0
2025-076A	STARLINK-32959	US	482	484	43	26	0	0
2025-077A	USA 521	US	NO INITIAL ELEMENTS			0	1	0
2025-077B	USA 522	US	NO INITIAL ELEMENTS					
2025-078A	SHIYAN 27A	PRC	1045	1047	99.69	5	1	0
2025-079A	USA 523	US	276	292	69.99	21	0	0
2025-080A	DRAGON CRS-32	US	404	409	51.64	0	0	0
2025-081A	KORSAT-3	SKOR	566	574	45.4	0	0	0
2025-081B	OBJECT B	TBD	573	575	45.39			
2025-082A	SZ-20	PRC	389	394	41.46	0	1	0
2025-083A	STARLINK-33879	US	481	485	43	27	0	0
2025-084A	TIANLIAN-2 05	PRC	35777	35794	5.38	0	1	0
2025-085A	STARLINK-11651	US	335	337	43	22	0	0
2025-086A	HULIANWANG DIGUI-20	PRC	1166	1169	86.5	9	0	0
2025-087A	STARLINK-33894	US	447	448	53.16	26	0	0
2025-088A	KUIPER-00008	US	486	499	51.87	26	0	0
2025-089A	STARLINK-11677	US	335	338	43	22	0	0
2025-090A	BIOMASS	ESA	668	670	98.08	0	0	0