National Aeronautics and Space Administration

Orbital Debris
Quarterly News

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Inside...

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Increase in ISS Debris Avoidance Maneuvers

Despite its mass of more than 410 metric tons, the International Space Station (ISS) must occasionally play dodge ball with the numerous man-made objects falling through its orbit (as shown in the figure below). For the first dozen years of its existence, the ISS averaged only one collision avoidance maneuver per year. However, in the past 12 months (April 2011 to April 2012), the ISS was forced to execute four collision avoidance maneuvers and would have conducted two additional maneuvers if the warnings had come sooner.

What is the reason for this increase in collision avoidance maneuvers? The process and the fidelity of conjunction assessments (*i.e.*, the calculations made to determine when a known object is expected to come within a few kilometers of the ISS) have remained unchanged for several years. The threat level at which a collision maneuver is required (collision risk greater than 1 in 10,000) also has remained the same. No new source of debris in the immediate vicinity of the ISS has appeared, as happened in 2008 when a Russian spacecraft (Cosmos 2421) broke-up into more than 500 pieces of tracked debris just 60 km above the ISS.

A simple statistical variation in the frequency of the close approaches does not appear to be the complete answer either. A likely contributing factor is the Sun (ODQN, January 2012, p. 4). Solar activity varies in a nearly sinusoidal pattern with a period of approximately 11 years. After an extended interval of very low solar activity from 2006 through 2010, the Sun is rapidly approaching an expected peak of activity in 2013. As solar activity increases, the Earth's atmosphere is heated and expands, resulting in increased drag on objects in low Earth orbit. This, in turn, leads to a higher number of objects falling through the ISS orbit (near 400 km) on their way to a fiery reentry.

For example, during 2011 approximately 500 cataloged debris descended through the ISS altitude. In comparison, the totals for 2009 and 2010 were less than 300 and less than 400, respectively. Half of the cataloged debris that reentered

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With a breadth of more than 100 meters, the International Station Space presents a large target for orbital debris.

ISS Collision Avoidance

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during 2011 came from the Chinese anti-satellite test of 2007 involving the Fengyun-1C satellite or the accidental collision of the Cosmos 2251 and Iridium 33 spacecraft in 2009, both of which occurred at altitudes several hundred kilometers above the ISS. Small fragmentation debris are especially affected by increases in solar activity. The table below indicates that four of the six close approaches involved debris from these two events.

Since solar activity is expected to increase further during 2012, the rate of orbital decay of debris in the low Earth orbit region should likewise increase, setting the stage for additional ISS collision avoidance maneuvers. ♦

Recent ISS Debris Collision Risks

Date of Maneuver or Close Approach	Object Avoided	Action Taken
2-April-2011	Fragmentation debris from Russian Cosmos 2251	Collision Avoidance Maneuver
28-June-2011	Debris apparently from Proton ullage motor breakup	Crew retreated to Soyuz due to insufficient time for maneuver
29-September-2011	Russian Tsyklon rocket body debris	Collision Avoidance Maneuver
13-January-2012	Fragmentation debris from Iridium 33	Collision Avoidance Maneuver
28-January-2012	Fragmentation debris from Fengyun-1C	Collision Avoidance Maneuver
24-March-2012	Fragmentation debris from Russian Cosmos 2251	Crew retreated to Soyuz due to insufficient time for maneuver

Orbital Debris Discussions at the United Nations

The Scientific and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) held its annual meeting at the UN complex in Vienna, Austria, during 6-17 February 2012. As it has since 1994, the subcommittee's agenda included the topic of orbital debris. Since the STSC completed its development of Space Debris Mitigation Guidelines in 2007, members of the STSC have been encouraged to report on the progress of their adoption of similar guidelines and their experiences in the implementation of the guidelines.

The United Nations Office of Outer Space Affairs (OOSA) is located in the UN complex in Vienna, Austria.

During the 2012 session, the United States, the Russian Federation, France, and Switzerland delivered special technical presentations on the subject of orbital debris. The U.S. presentation, delivered by the NASA Chief Scientist for Orbital Debris, provided an overview of the entire Earth satellite population, including new launches, major debris clouds, and reentries, followed by U.S. actions during the previous year involving collision avoidance maneuvers and the spacecraft disposal operations. The Russian Federation highlighted recent work by the International Scientific Optical Observation Network (ISON) on observations near the geosynchronous region. ISON is now comprised of 42 telescopes distributed among 12 countries, and it maintains a database on more than 1700 objects.

France provided an overview of its space activities in 2011, including the retirement of three satellites in low Earth orbit (LEO) and one in geosynchronous orbit (GEO). During the year, France operated 18 spacecraft and conducted 5 maneuvers to avoid potential collisions. Switzerland summarized its work with optical telescopes in support of both national and European Space Agency objectives. The International Association for the Advancement of Space Safety (IAASS), a non-governmental organization, made two presentations covering the topics of satellite servicing, active debris removal, and reentry hazards.

Also on the agenda for the STSC meeting was the subject of long-term sustainability of outer space activities (LTSSA) (ODQN, April 2011, p. 1). The new working group on LTSSA is divided into four expert groups:

Expert Group A is addressing sustainable space utilization supporting sustainable development on Earth;

Expert Group B is devoted to the topics of space debris, space operations, and tools to support collaborative space situational awareness;

Expert Group C is focused on space weather; and

Expert Group D is investigating regulatory regimes and guidance for actors in the space arena.

Inputs to each of the expert groups are being provided, not only by UN member

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Orbital Debris Discussions

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states, but also by national and international industrial and professional organizations. Under the official STSC work plan, best practice guidelines for all LTSSA areas will be developed by the time of its meeting in 2014. The expert groups will meet again in June during the annual meeting of the full COPUOS.

All technical presentations from the 2012 sessions of STSC, including those related to a special LTSSA workshop, can be downloaded from http://www.oosa.unvienna.org/oosa/en/COPUOS/stsc/2012/presentations.html . ♦

Controlling Rocket Body Reentry Risks

During 2011, launch vehicle upper stages dropped from Earth orbit at a rate of one per week. While the number of uncontrolled orbital stage reentries for all of last year was more than twice that of uncontrolled spacecraft, the total mass of these reentering stages was five times that of the uncontrolled spacecraft, posing risks to both people and property on the ground. Consequently, greater emphasis is now being placed internationally on curtailing the uncontrolled reentry of launch vehicle stages.

For example, the second stage of the launch vehicle which carried the ill-fated Phobos-Grunt spacecraft to a low Earth orbit in November 2011 reentered in an uncontrolled manner 2 weeks later with a dry mass greater than the combined masses of the UARS and ROSAT spacecraft, whose reentries garnered headlines around the world just 2 months earlier. Historically, launch vehicle stages also represent the majority of reentry debris recovered each year around the world.

Several launch vehicle orbital stages are known to exceed a human casualty risk of 1 in 10,000, a standard adopted by organizations in the U.S., Europe, and Japan. In turn, the greater awareness of reentry risks has led launch vehicle operators to increasingly examine and, where feasible, adopt either controlled reentry profiles or the use of disposal orbits above 2000 km, from which orbital decay intervals are measured in millennia. For missions to low Earth orbit (LEO), controlled reentries are almost always more efficient than high altitude disposal orbits, although in 2009 an Atlas V Centaur stage was sent on an Earth escape trajectory after deploying a meteorological satellite in LEO, in part, to satisfy secondary objectives.

From 2006 through 2010, controlled reentries of launch vehicle upper stages were rare, averaging only one per year. However, in 2011 a record number of launch vehicle stages – eight in all – were intentionally placed on destructive paths over broad ocean areas. Moreover, these missions included stages from the United States, France, Japan, and the Russian Federation. The previous year China deliberately reentered stages from two different space missions. Plans are currently being made for a controlled reentry later this year for the Atlas V Centaur stage to be used to support NASA's Radiation Belt Storm Probes mission. ♦

Large launch vehicle orbital stages, like this Atlas V Centaur stage, can pose human casualty risks exceeding widely accepted norms.

Stranded Satellite Sent on Controlled Reentry

A Russian communications satellite, stranded in an elliptical orbit since last summer, was sent to a destructive reentry over the northern Pacific Ocean on 25 March 2012. The Express-AM4 (International Designator 2011-045A, U.S. Satellite Number 37798) was launched on 17 August 2011 by a Proton rocket from the Baikonur complex in Kazakhstan. Unfortunately, the Breeze M upper stage malfunctioned and released its 5.7-metric-ton payload into a transfer orbit that was far short of the planned apogee. Although operational, Express-AM4 had insufficient propellant of its own to reach a geosynchronous orbit and conduct the mission for which it was designed.

By late March 2012, Express-AM4 was still in a long-lived orbit of approximately 660 km by 20,300 km with an inclination of 51 degrees. After considering a variety of options, a decision was made to perform a controlled reentry with the European-built vehicle to avoid the risk of future collisions with other objects in Earth orbit. As the spacecraft neared apogee on the morning of 25 March, its

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Express-AM4 spacecraft as it would have appeared in geosynchronous orbit. (Credit: EADS Astrium)

Stranded Satellite

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engine was ignited to lower perigee, ensuring a reentry a few hours later over an uninhabited broad ocean area.

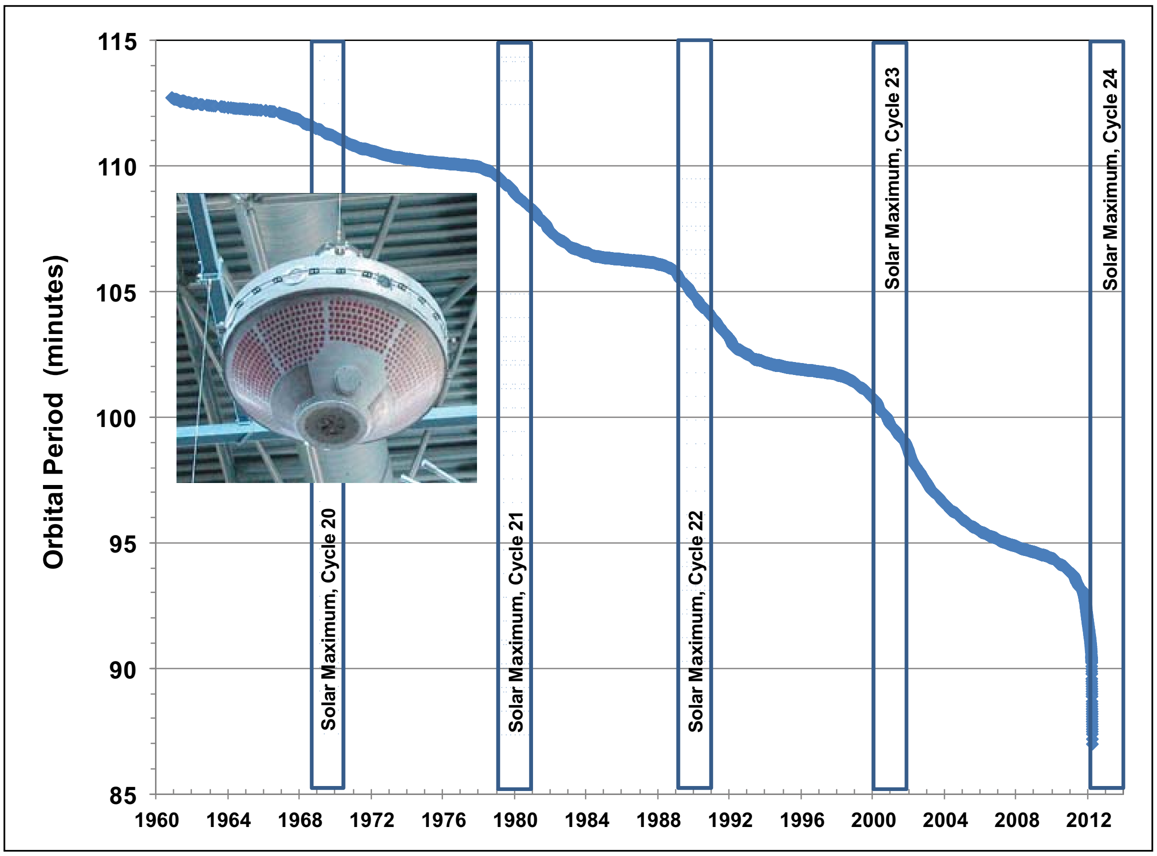
This was not the first time that a stranded communications satellite had been intentionally de-orbited. On 10 December 2002, the Astra-1K spacecraft suffered a similar fate after being left in a very low parking orbit by another Proton launch failure. ♦

Reentry of Explorer 8 Satellite

After more than half a century in Earth orbit, one of NASA's oldest spacecraft finally fell back to Earth on 28 March 2012. Launched on 3 November 1960, Explorer 8 was designed to study the ionosphere and meteoroids. Although limited to an operational lifetime of only 2 months by its non-rechargeable batteries, the spacecraft returned valuable information about the then poorly understood near-Earth space environment.

The ~40-kg Explorer 8 (International Designator 1960-014A, U.S. Satellite Number 60) was inserted into an elliptical orbit with a perigee of about 420 km and an apogee near 2290 km at an inclination of 50 degrees. With a perigee below 500 km, the orbit of Explorer 8 was highly influenced by solar activity, as shown in the figure. During the regular 11-year peaks of solar activity, increased drag on the spacecraft caused it to lose energy at increasing rates, dropping into lower period orbits.

By the beginning of 2010, when solar activity began its rise from an extended quiet period, the orbit of Explorer 8 was only ~350 km by 630 km, and its days in orbit were clearly numbered. Few, if any, components of the aluminum spacecraft were expected to reach the surface of the Earth. ♦



The orbital decay of Explorer 8 was principally influenced by the periodic increases in solar activity. A full-scale replica of Explorer 8 is on display at the Smithsonian's Steven F. Udvar-Hazy Center near Washington, DC.

Chinese Rocket Body Explosions Continue

For the fourth time in 5 years, the third stage of a Chinese Long March 3 (CZ-3) launch vehicle has exploded shortly after delivering its payload to a highly elliptical geosynchronous transfer orbit (GTO). The most recent event occurred on 26 February 2012, within 2 days of the successful launch and release of the vehicle's Beidou G5 navigation satellite.

After lift-off from the Xichang Satellite Launch Center on 24 February 2012, the third stage of a CZ-3C launch vehicle (International Designator 2012-008B, U.S. Satellite Number 38092) carried the Beidou 5G satellite to an orbit of approximately 200 km by 36,000 km with an inclination of 21 degrees. The third stage, with a dry mass of 3 metric tons, a length of 12.4 meters, and a diameter of 3 meters, remained in this GTO orbit, while its payload propelled itself into a geosynchronous orbit. Two days after launch, the U.S. Space Surveillance Network (SSN) detected dozens of debris associated with a severe fragmentation of the stage. To date only one of these debris, believed to be the vehicle equipment bay (VEB), has been officially cataloged.

Following two serious explosions of Long March 4 stages in low Earth orbit in 1990 and 2000, respectively, China established a

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Explosions Continue

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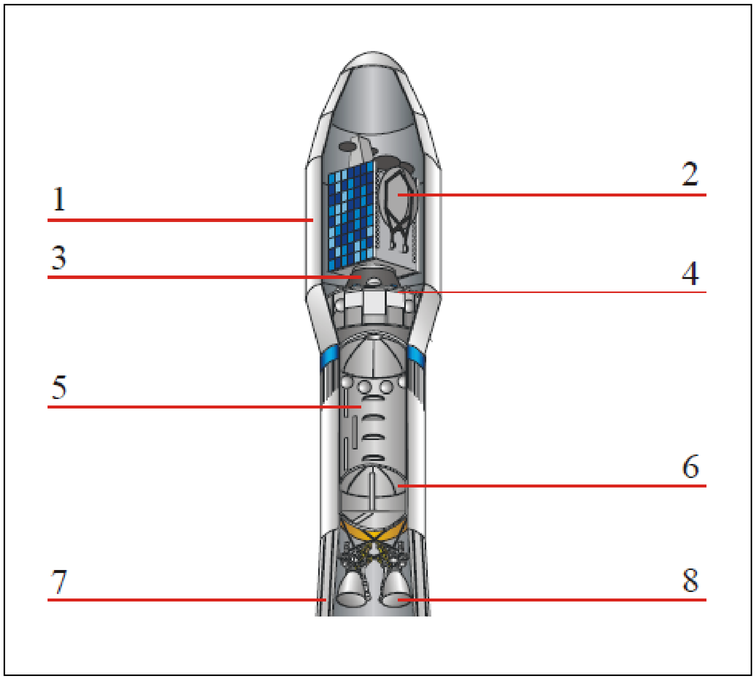
requirement in 2005 to deplete all residual propellants from orbital stages after payload separations. Such passivation measures have been implemented for the Long March 2 and Long March 4 series launch vehicles, which employ hypergolic propellants in their final stages. However, according to a report from the China National Space Administration (CNSA) in 2011, efforts to design passivation procedures for Long March 3 third stages, which burn liquid hydrogen and liquid oxygen, had not yet been completed [1]. The same report stated that the typical amounts of residual hydrogen and oxygen were 110 kg and 500 kg, respectively.

The three previous CZ-3 third stage explosions occurred in February 2007, November 2010, and December 2011, and each took place within 2 days of launch. Although 30 new debris were cataloged with the first event, no new debris were cataloged with the other two breakups. In part, this is due to SSN limitations in observing small debris in low inclination, highly elliptical orbits. One of the stages (International Designator 2010-057B, U.S. Satellite Number 37211) reentered the atmosphere in late September 2011. Presumably, all or most of its associated debris have already reentered.

<u>Reference</u>

1. *Space Debris Research, Special 2011*, China National Space Administration, National Aerospace Information Center of China, Beijing. ♦



CZ-3C third stage and sample payload. 1 = fairing, 2 = spacecraft, 3 = payload adaptor, 4 = vehicle equipment bay, 5 = liquid hydrogen tank, 6 = liquid oxygen tank, 7 = interstage section, 8 = third stage engine.

French Launch Vehicle Debris Lands in Brazil

The small village of Anapurus in the Brazilian state of Maranhao was the recipient of an unexpected visitor in the early morning of 22 February 2012. A spherical tank from a French Ariane 4 launch vehicle landed in the village, damaging a few trees but causing no injuries. Part of the third stage of the launch vehicle that carried communications spacecraft for Thailand and Japan, the tank, with a diameter of one meter, had been in orbit for 15 years, since its launch on 16 April 1997 from nearby French Guiana.

After releasing its two payloads, the Ariane stage was left in an orbit of approximately 250 km by 36,260 km with an inclination of only 7 degrees. This meant that the stage never ventured further north than 7 degrees north latitude or further south than 7 degrees south latitude. Hence, its future reentry would be constrained within this narrow equatorial band.

The Joint Space Operations Center (JSpOC) of the U.S. Strategic Command began issuing Tracking and Impact Prediction (TIP) messages for the stage (International Designator 1997-016C, U.S. Satellite Number 24770) on 18 February, 4 days prior to reentry. The post-reentry assessment by the JSpOC indicated atmospheric interface at 0909 GMT at approximately 4 degrees south latitude, 48 degrees west longitude, heading eastward. This time and location were consistent with the landing of the tank in Anapurus, which has coordinates of approximately 4 degrees south and 43 degrees west.

On average, only one or two objects which survive the intense reentry environment are recovered each year somewhere in the world. Most surviving debris impact the oceans or other bodies of water or land in desolate regions, where they are either not found or not recognized as a spacecraft or launch vehicle component. ♦

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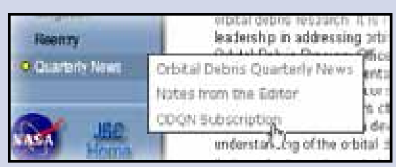


PROJECT REVIEW

On the Probability of Random Debris Reentry Occuring on Land or Water, Part II

M. MATNEY

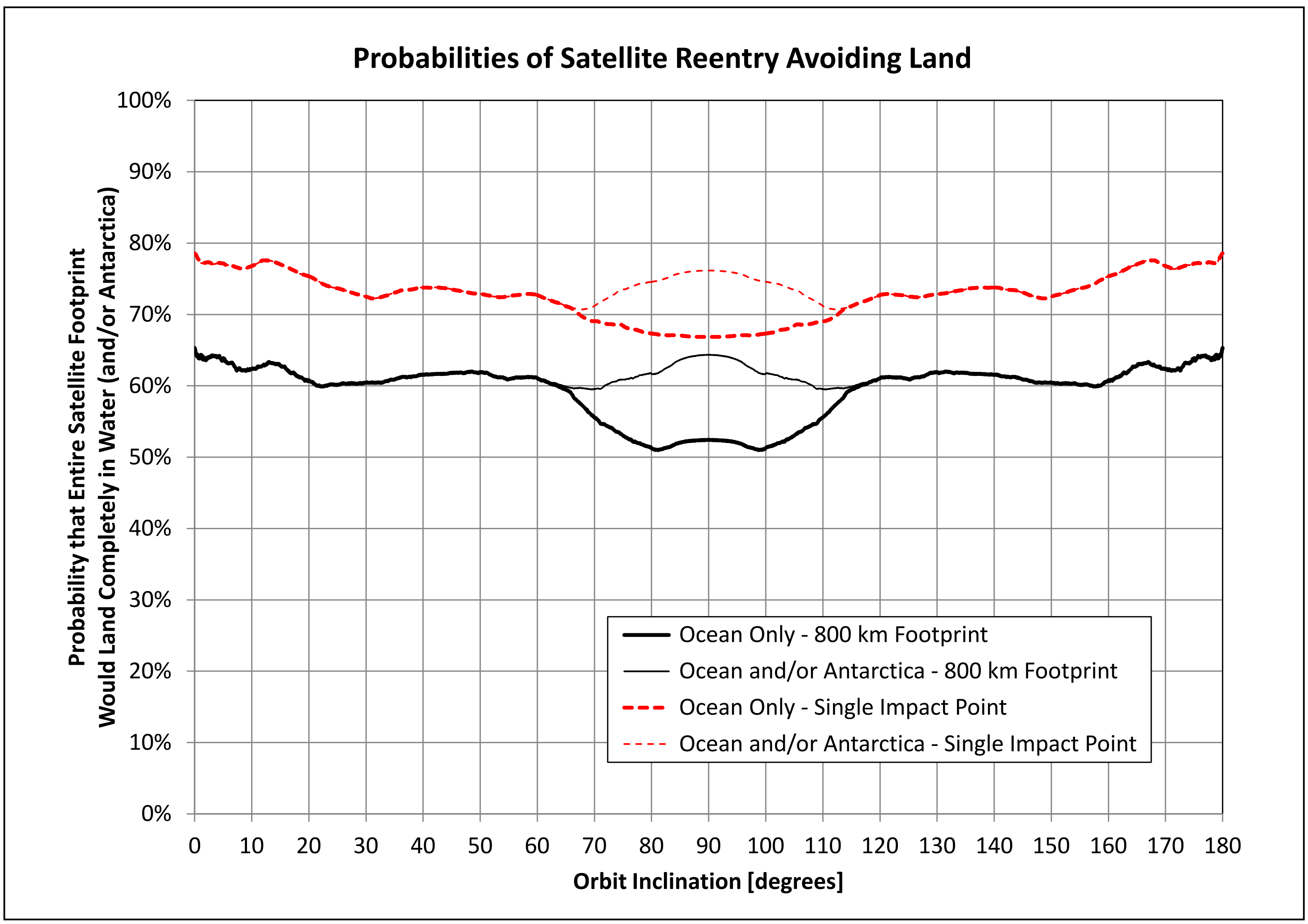
In the January 2012 issue of the ODQN, I presented information on the probability that an individual reentering object would fall on land or water. Because I treated the satellite as a single object, the calculations were relatively straightforward. In reality, however, large reentering objects break up into multiple pieces that can survive reentry. So, a more relevant question would concern the probability that individual pieces of a reentry breakup would fall on land or water. Actually computing this probability is much more difficult, requiring detailed knowledge of an individual satellite and its reentry footprint.

It is possible, however, to compute the answer to a more general question. Given the size of a reentry footprint, what is the probability that none of that reentry footprint would fall on land? The calculation is more complicated because it involves the complex interaction of the ground path of the orbit arc with the irregular shapes of land forms on Earth, but can easily be accomplished using the database described in my previous ODQN article.

For simplicity, I have assumed that the reentry footprint has no "width," so that the debris fall along the ground path of the orbit. I have chosen for the "generic" reentry, a ground footprint arc length of 800 km.

The chart shows the results of this calculation, with the probability of the reentry footprint falling completely over water. Also shown are the data for a single object reentry (given here as the probability of landing on water) for comparison. I have also included the contribution from the Antarctic land mass.

The effect of the extended reentry footprint is to lower the probability that the reentry would occur completely over water, as might be expected. Nevertheless, for most orbits, this probability exceeds 60%. Note that if reentries over the continent of Antarctica are ignored, this probability is mostly inclination-independent. ♦



This chart shows the probability that a reentering object will land completely in water as a function of orbit inclination. The black solid curves are computed assuming an 800 km-long reentry footprint. The red dotted curves are for a single object point reentry. In both cases, the effects of the continent of Antarctica are shown by showing the curve if Antarctica were considered "water."

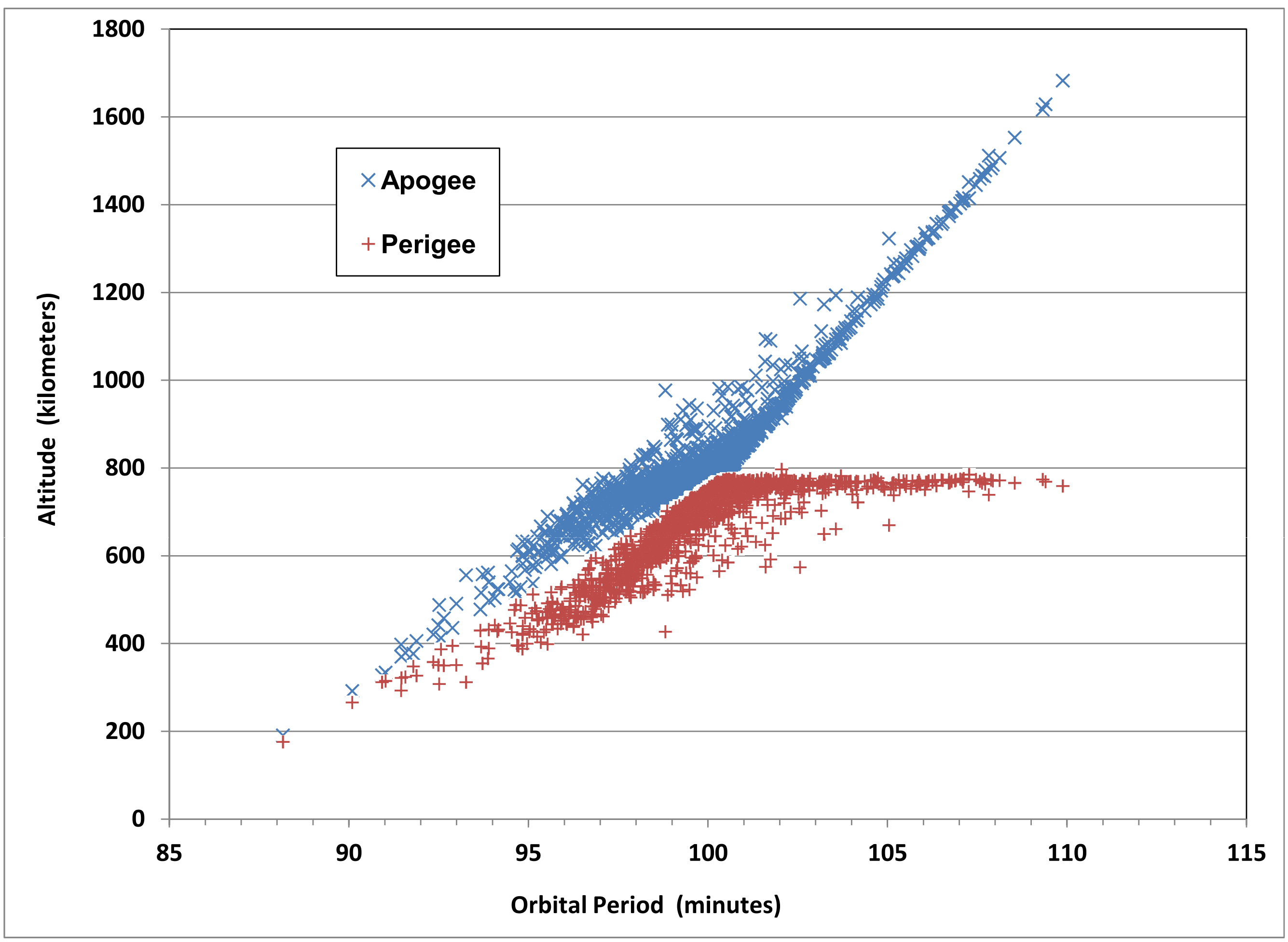
MEETING REPORT

The International Symposium on Sustainable Space Development and Utilization for Humankind: Orbital Space Debris – Challenges & Opportunities 1-2 March 2012, Tokyo, Japan

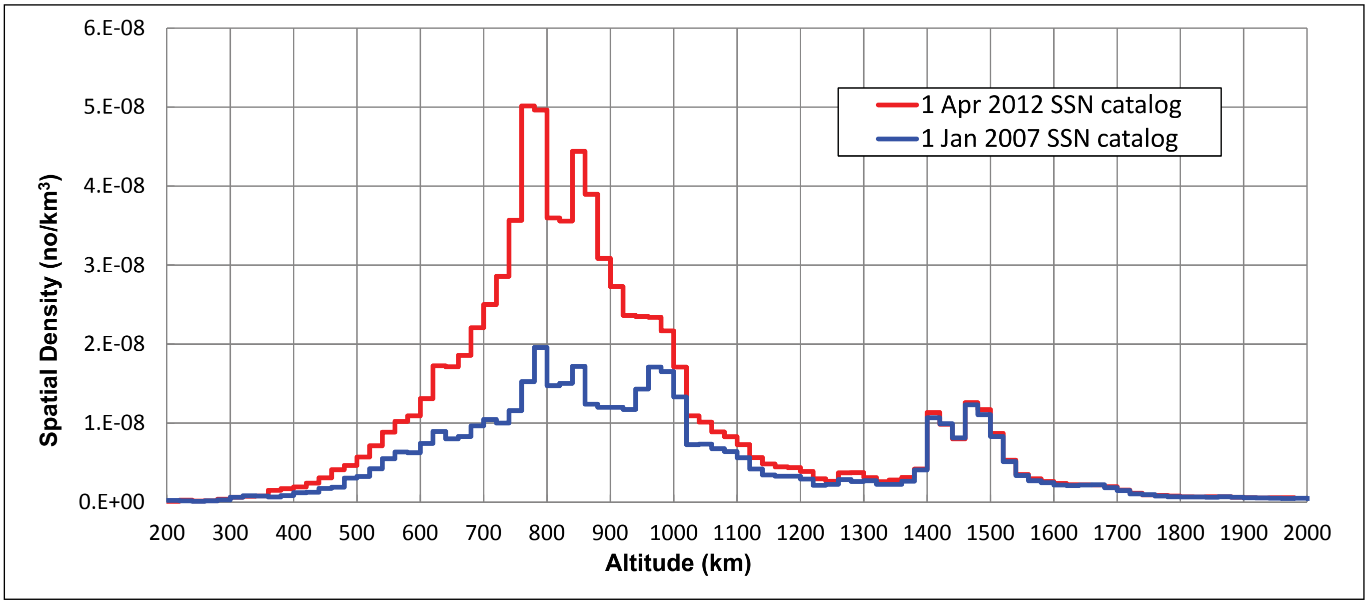
The Japan Space Forum (JSF) hosted the International Symposium on Sustainable Space Development and Utilization for Humankind: Orbital Space Debris – Challenges & Opportunities on 1-2 March 2012 in Tokyo. The prestigious speakers list included Mr. M. Furukawa, Minister of State for Space Development; Mr. Y. Muto, Deputy Director-General, Ministry of Foreign Affairs; Mr. K. Totani, Director General, Ministry of Education, Culture, Sports, Science and Technology; Mr. K. Higuchi, Vice President, JAXA; and Mr. H. Yamakawa, Secretary General, Secretariat of Strategic Headquarters of Space Policy, Cabinet Secretariat, Gov't of Japan. For the United States, speakers included Mr. F. Rose, Deputy Assistant Secretary for Space and Defense Policy, U.S. Dept. of State; Mr. R. McKinney, Deputy Under Secretary of the Air Force for Space Programs, U.S. Dept. of Defense; Mr. J. Finch, Director, Space Policy and Strategy, Office of the Secretary of Defense; Brig. Gen. K. Story, Deputy Commander, Joint Functional Component Command Space; and Mr. E. Stansbery, Program Manager, NASA Orbital Debris Program Office.

The symposium's focus was on Japan's desire to improve its capabilities in the area of Space Situational Awareness (SSA) and future collaboration with the U.S. and European partners in SSA information sharing.

Following the 2-day meeting in Tokyo, interested parties were invited to tour the Bisei and Kamisaibara Spaceguard Centers, both owned by the JSF. Bisei is the home to two large telescopes (1 m and 0.5 m apertures) used for orbital debris research and Near Earth Object searches. Kamisaibara is home to Japan's S-band radar test bed, used to test SSA operations. The JSF discussed their plans to significantly upgrade the radar to a 6 m x 6 m phased array, comparable in sensitivity to the current U.S. Space Surveillance Network. ♦



By the third anniversary of the accidental collision of the Russian Cosmos 2251 spacecraft and the U.S. Iridium 33 spacecraft, 2126 debris had been officially cataloged by the U.S. Space Surveillance Network. Of these, 1859 (87%) remained in orbits scattered between 200 km and 1700 km above the surface of the Earth. The above graphic depicts the distribution of debris orbits (a symbol for each apogee and perigee) in February 2012. More than 160 additional debris from the collision were being tracked but had not yet been officially cataloged.



The spatial density distribution of the cataloged objects on 1 April 2012 (red histogram). The population below 1000 km altitude is more than doubled since the beginning of 2007 (blue histogram). Fragments generated from the anti-satellite test (at 850 km altitude) conducted by China in 2007 and the collision between Iridium 33 and Cosmos 2251 (at 790 km altitude) in 2009 were responsible for the majority of the increase.

UPCOMING MEETINGS

14-22 July 2012: The 39th COSPAR Scientific Assembly, Mysore, India

The theme for the space debris sessions for the 39th COSPAR is "Steps toward Environment Control." Topics to be included during the sessions are advances in ground- and space-based surveillance and tracking, in-situ measurement techniques, debris and meteoroid environment models, debris flux and collision risk for space missions, on-orbit collision avoidance, re-entry risk assessments, debris mitigation and debris environment remediation techniques and their effectiveness with regard to long-term environment stability, national and international debris mitigation standards and guidelines, hypervelocity impact technologies, and on-orbit shielding concepts. Additional information about the event can be found at <http://www.cospar-assembly.org/>.

11-14 September 2012: The 13th Advanced Maui Optical and Space Surveillance (AMOS) Technologies Conference, Maui, Hawaii

The 13th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS) will be held in Maui, Hawaii on 11-14 September 2012. This conference will provide a forum for sharing the latest research and technology developments in space surveillance and optics, and high performance computing. One of the technical sessions is dedicated to orbital debris. This year's AMOS will also include a keynote address by the Commander of Air Force Space Command, General William Shelton. Additional information about the conference is available at <http://www.amostech.com/>.

16-20 September 2012: The 2012 Hypervelocity Impact Symposium (HVIS), Baltimore, Maryland

This biennial event is organized by the Hypervelocity Impact Society to promote research and development in the high and hypervelocity impact areas. The topics to be covered in the 2012 HVIS include hypervelocity phenomenology, high-velocity launchers, spacecraft micrometeoroid and orbital debris shielding, material response and equation of state, fracture and fragmentation physics, analytical and numerical modeling, advanced and new diagnostics. Additional information about the symposium can be found at <http://hvis2012.org/>.

1-5 October 2012: The 63rd International Astronautical Congress (IAC), Naples, Italy

The theme for the 2012 IAC is "Space science and technology for the needs of all." Just like the previous IACs, a Space Debris Symposium is planned. It will address all aspects of space debris research and technology development. A total of six sessions are scheduled for the symposium on measurements, modeling and risk analysis, hypervelocity impacts and protection, mitigation and standards, and space debris removal issues. In addition, a joint session with the Space Security Committee on "Political, Economic, and Institutional Aspects of Space Debris Mitigation and Removal" will be held to address the non-technical issues associated with future debris removal. Additional information about the 63rd IAC can be found at <http://www.iac2012.org/>.

INTERNATIONAL SPACE MISSIONS
01 January – 31 March 2012

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2012-001A	ZY 3	CHINA	498	506	97.5	1	0
2012-001B	VESSELSAT 2	LUXEMBOURG	486	499	97.5		
2012-002A	FENGYUN 2F	CHINA	35759	35813	2.2	2	0
2012-003A	WGS F4 (USA 233)	USA	35786	35787	0.0	1	0
2012-004A	PROGRESS-M 14M	RUSSIA	381	399	51.6	1	0
2012-005A	NAVID	IRAN	276	374	56.0	1	0
2012-006A	LARES	ITALY	1435	1453	69.5	1	0
2012-006B	ALMASAT-1	ITALY	313	1431	69.5		
2012-006C	OBJECT C*	TBD	305	1419	69.5		
2012-006D	OBJECT D*	TBD	306	1419	69.5		
2012-006E	OBJECT E*	TBD	307	1419	69.5		
2012-006F	OBJECT F*	TBD	307	1415	69.5		
2012-006G	OBJECT G*	TBD	307	1416	69.5		
2012-006H	OBJECT H*	TBD	308	1420	69.5		
2012-006J	OBJECT J*	TBD	308	1421	69.5		
2012-007A	SES 4	USA	35782	35792	0.0	1	1
2012-008A	BEIDOU G5	CHINA	35777	35794	1.8	1	1
2012-009A	MUOS	USA	35784	35787	5.1	1	0
2012-010A	ATV-3	ESA	381	399	51.6	1	0
2012-011A	INTELSAT 22	INTELSAT	EN ROUTE TO GEO			1	1
2012-012A	COSMOS 2479	RUSSIA	35899	35908	2.3	2	1
2012-013A	APSTAR 7	CHINA	EN ROUTE TO GEO			1	0

* Seven small satellites were also deployed but their official satellite numbers have not yet been assigned. They are e-St@r (Italy), Goliat (Romania), Ma Sat 1 (Hungary), PW-Sat 1 (Poland), Robusta (France), UniCubeSat GG (Italy), and Xatcobeo (Spain).

SATELLITE BOX SCORE
(as of 04 April 2012, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	120	3466	3586
CIS	1416	4639	6055
ESA	42	45	87
FRANCE	54	434	488
INDIA	47	129	176
JAPAN	117	71	188
USA	1166	3673	4839
OTHER	521	112	633
TOTAL	3483	12569	16052

DAS 2.0 NOTICE

Attention DAS 2.0 Users: an updated solar flux table is available for use with DAS 2.0. Please go to the Orbital Debris Website (http://www.orbitaldebris.jsc.nasa.gov/mitigate/das.html) to download the updated table and subscribe for email alerts of future updates.

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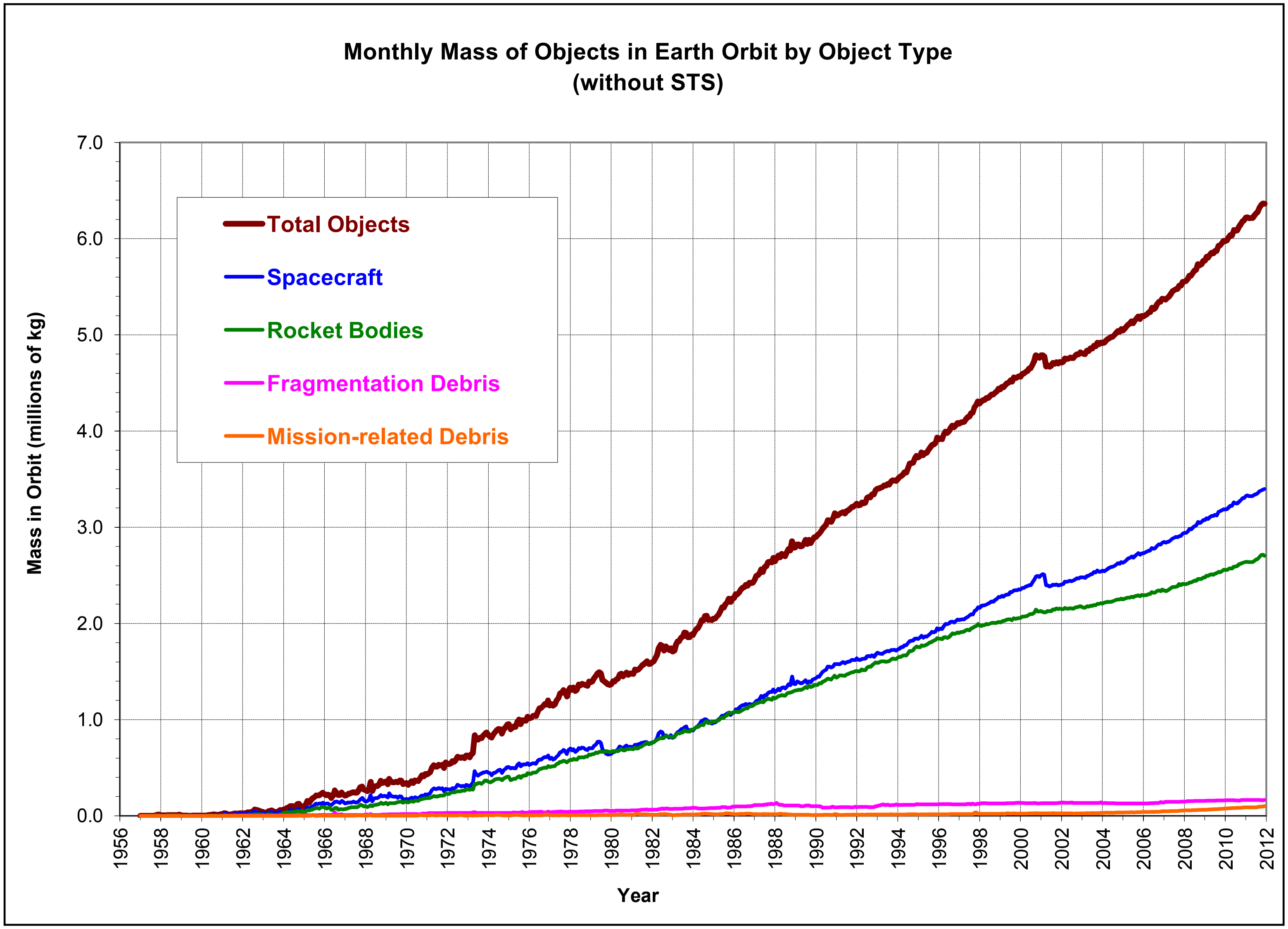

Monthly Mass of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission. Data for the Shuttle Transportation System (STS) is not included in this chart.

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