



# Orbital Debris Quarterly News

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## Inside...

New Evidence of Particle Impact on Jason-1 Spacecraft .....2

Reentry of U.S. Rocket Stage Over South America .....3

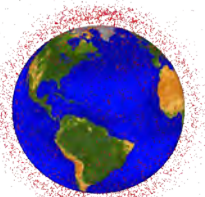
50th Anniversary of First On-Orbit Satellite Fragmentation .....3

MMOD Impacts on ISS Airlock Shields .....5

A Note on Active Debris Removal .....7

Meeting Report .....9

Space Missions and Satellite Box Score .....10



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## International Space Station Again Dodges Debris

For the fifth time in 2 1/2 years, the International Space Station (ISS) had to execute a collision avoidance maneuver in early April to ensure a safe miss distance for a piece of orbital debris. As solar activity increases during the next few years, the frequency of ISS collision avoidance might increase as many hundreds of resident space objects drift down through the ISS orbital regime.

The subject of concern in late March 2011 was a fragment from Cosmos 2251, the Russian communications satellite which had accidentally collided with the U.S. Iridium 33 communications satellite in February 2009, producing more than 2000 large debris. Designated as Satellite Number 34443 in the U.S. Satellite Catalog (International Designator 1993-036SL), the fragment had an apparent size of 10-15 cm. Initially thrown into a moderately elliptical orbit by the 2009 collision, the debris had spent essentially its entire orbital lifetime passing through the orbital regime of the ISS many times each day (Figure 1).

On 30 March a collision risk in excess of 1 in 10,000 (the threshold above which collision avoidance maneuvers are normally dictated) was predicted to occur on three successive revolutions

during 2 April if no action was taken. Additional tracking data was acquired, and new predictions were performed, leading to even higher calculated values of probability of collision. A plan was developed to use the European Automated Transfer Vehicle 2 (ATV-2), which had docked at the aft end of the ISS complex on 24 February, to conduct a small evasive maneuver. The burn, which lasted 3 minutes and 18 seconds, was executed early 2 April (GMT), imparting a change in velocity to ISS of only 0.5 meters per second.

This maneuver was the 12<sup>th</sup> collision avoidance maneuver conducted by ISS since October 1999.

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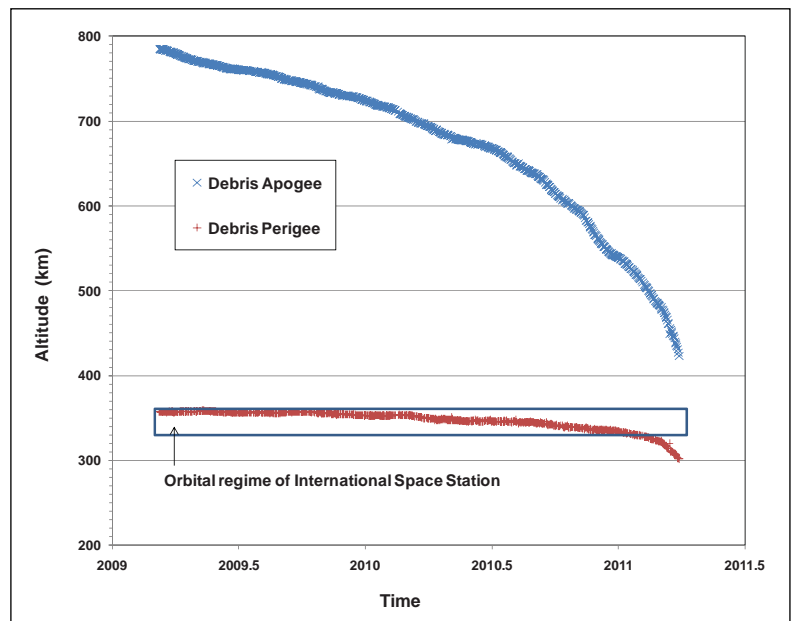


Figure 1. Orbital decay of debris which caused the ISS collision avoidance maneuver.

## ISS Dodges Debris

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Although maneuvers prior to 2008 had been required to evade intact spacecraft or launch vehicle stages, the last five maneuvers were caused by decaying fragmentation debris. The four events prior to 2011 involved debris from the Russian Cosmos 2421 spacecraft (27 August 2008), from a Chinese launch vehicle stage (22 March 2009), from a Russian launch vehicle

stage (18 July 2009), and from the NASA UARS spacecraft (26 October 2010).

In late June another close approach by a tracked, but uncataloged, debris was identified, leading to a calculated probability of collision on the order of 1 in 360, with a miss distance of 725 m. However, due to the rapidly changing elliptical orbit of the debris, insufficient time

was available to prepare for and to conduct a collision avoidance maneuver. As a precaution, on 28 June the six members of the ISS crew retreated to the two attendant Soyuz transport ships to be ready to undock and return to Earth should a collision occur. In the end, the debris passed the ISS without further incident, and the crew returned to their normal duties. ♦

## New Evidence of Particle Impact on Jason-1 Spacecraft

Nine years after the event, new analyses indicate that the joint U.S.-French spacecraft Jason-1 was struck by a high-speed particle only three months after launch. Although at least two detectable debris were generated, the spacecraft continues to this day to provide valuable data on the topography of the Earth's oceans.

Following a launch from Vandenberg AFB in California by a Delta 2 rocket on 7 December 2001, Jason-1 (International Designator 2001-055A, U.S. Satellite Number 26997) quickly reached its operational orbit of 1336 km with an inclination of 66 degrees, where it coordinated operations with the earlier U.S.-French spacecraft TOPEX/Poseidon. However, on 16 March 2002, spacecraft controllers noted a distinct attitude upset of the vehicle. A detailed study of the spacecraft's perturbations suggested that a small particle had struck the

left solar array from above on the segment closest to the main structure (Figure 1). The attitude upset was accompanied by a temporary (a few hours) electrical current disturbance.

Although not linked, at the time, to the spacecraft anomaly, the U.S. Space Surveillance Network (SSN) soon detected two new objects in orbits slightly lower than that of Jason-1 (Figure 2). The debris were determined to have been ejected from the spacecraft with moderate velocities of 24 and 46 meters per second, respectively. Both debris are also small (less than 20 cm) and exhibit relatively large area-to-mass ratios ( $> 2 \text{ m}^2/\text{kg}$ ).

Subsequent orbital analyses by SSN specialists indicated that the debris indeed originated from Jason-1 on 16 March 2002, although the objects were not officially cataloged until 2009 and 2011 as Satellite Numbers 35414 and 37379.

It is not possible to discern whether the impacting particle was natural or man-made. At the altitude of Jason-1, the orbital debris population is relatively slight. Jason-1 experienced a second anomaly (including temporary loss of command) in 2005, but there is no evidence that the event was caused by a particle impact. ♦

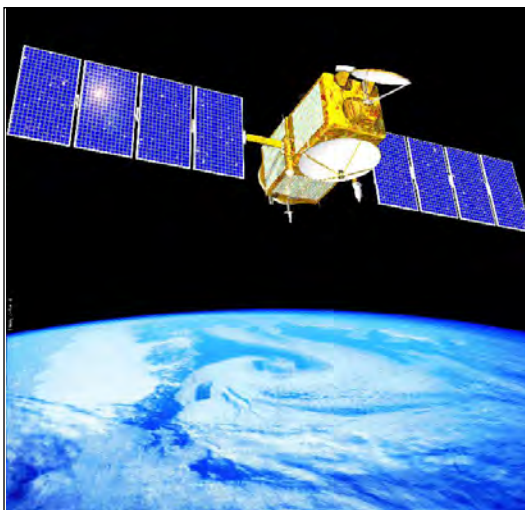


Figure 1. Jason-1 spacecraft configuration.

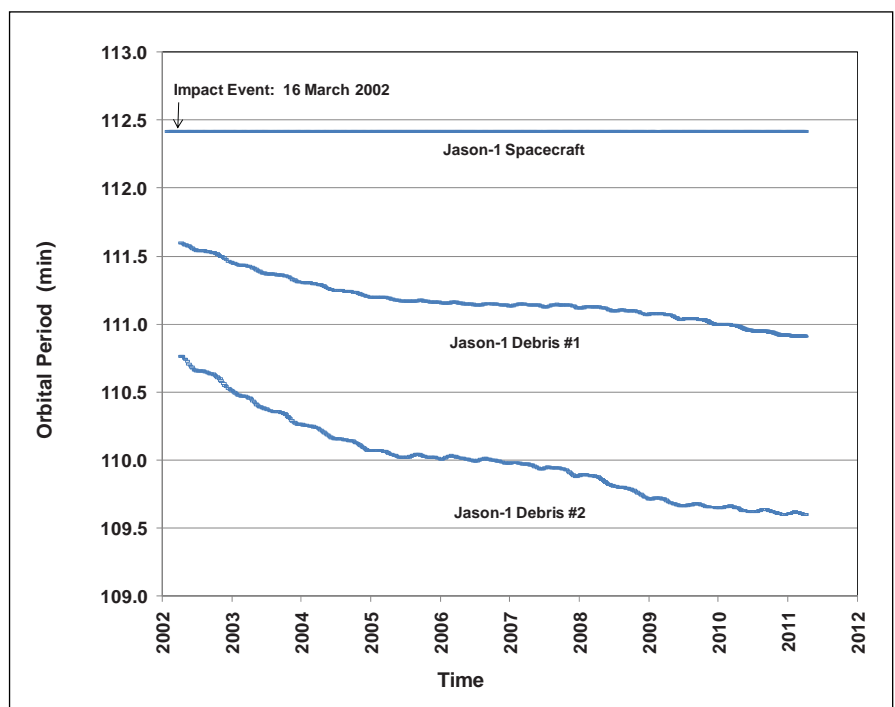


Figure 2. Orbital history of Jason-1 and two debris released in March 2002.

# Reentry of U.S. Rocket Stage over South America

In early March 2011, the titanium casing of a solid rocket motor (SRM) landed harmlessly in northern Uruguay. A remnant of the third stage of a U.S. Delta 2 rocket which had been in orbit for 7 years, the former orbital debris had a diameter of 1.2 m and an estimated mass of about 50 kg upon impact.

The Delta 2 was launched on 21 December 2003 on a successful mission to place a new Global Positioning Satellite (GPS), Navstar 53, into a circular, semi-synchronous orbit. The third stage of the launch vehicle (International Designator 2003-058C, U.S. Satellite Number 28131) lifted the spacecraft from a low Earth orbit into a highly elliptical transfer orbit of approximately 180 km by 20,300 km with an inclination of 39 degrees. Using a separate

SRM, Navstar 53 inserted itself into the desired operational orbit, leaving the ~230-kg Delta 2 third stage to gradually fall back to Earth.

Reentry began over the Pacific Ocean as the stage, known as a Payload Assist Module or PAM-D, approached South America. Traveling over Chile and Argentina, the STAR-48B SRM casing, sans nozzle, came to rest near the town of Artigas, Uruguay, at about 10:00 pm local time on 2 March (Figure 1). This was the fourth report in 10 years of a STAR-48B casing being found after reentry. Earlier recoveries occurred in Saudi Arabia (2001), Argentina (2004), and Thailand (2005) (see ODQN, April 2001, p. 1; April 2004, p. 1; and April 2005, p. 2). All four SRMs had supported GPS missions. ♦



Figure 1. STAR-48B motor casing which landed in Uruguay during the evening of 2 March 2011 (local time).

## PROJECT REVIEW

### Fiftieth Anniversary of First On-Orbit Satellite Fragmentation

N. JOHNSON

On 29 June 1961, a U.S. Ablestar upper stage exploded into nearly 300 large pieces, overwhelming the then official total Earth orbital population of only 54 objects. The 50<sup>th</sup> anniversary of this seminal event was marked this year with both reflection and optimism: reflection on the more than 200 known satellite fragmentations which followed and optimism that current space vehicle designs and operations will continue to curtail such accidental occurrences in the future.

The Ablestar stage (International Designator 1961-015C [aka 1961-Omicron 3], U.S. Satellite Number 118) lofted the Transit 4A spacecraft along with two smaller scientific satellites, Injun 1 and Solrad 3, into an orbit 880 km by 1000 km with an inclination of 67 degrees. Transit 4A was one of the early members of the first global navigation satellite system and carried the first nuclear power supply into space, the SNAP-3 radioisotopic thermoelectric generator (RTG). Although the piggyback satellites failed to separate from one another, the mission was deemed successful with the Ablestar stage completing all of its required tasks. However, just 77 minutes after orbital insertion, the stage violently came apart, throwing debris across the entire low Earth

orbit (LEO) region with some of the fragments reaching to altitudes above 2000 km.

Despite the rudimentary nature of space surveillance sensors in the early 1960s, this satellite breakup remains one of the best documented since the vehicle was being observed with both radio and optical means at the time of the event. From a southeasterly launch from Cape Canaveral, Florida (Figure 1), the Ablestar stage led the Transit 4A and the still-joined Injun 1 and Solrad 3 satellites as the trio passed for the first time over the western United States. At 0608 GMT a Baker-Nunn camera in Organ Pass, New Mexico, clearly photographed the three distinct vehicles, while an electronics van in Downey, California, received a beacon signal from Ablestar (Figure 2). Seconds later, the signal reception ceased, and the image of the Ablestar stage became a blur.

The explosion of an artificial satellite was unprecedented, but within only weeks over 100 debris had been identified. As the capability of the U.S. Space Surveillance Network (SSN) improved over the years, the number of known large debris (>10 cm) from the approximately 600-kg Ablestar gradually grew to reach 293 in June 1992, 31 years after its explosion. [Three of the 296 debris officially cataloged with this event are now known to have originated with

other breakup events.] Due to the high altitude of the event, 60% of these debris (176 in all) remain in Earth orbit today (Figure 3).

A thorough investigation into the possible causes for the catastrophic event was immediately undertaken. A preliminary report identified two basic mechanisms which might have caused the stage to break apart: the mixing of the hypergolic propellants prior to break-up or the explosive depressurization of the propellant tanks to allow non-explosive burning of the propellants. At the time of the explosion, the stage contained an estimated

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Figure 1. Launch of Transit 4A on 29 June 1961.

# Fiftieth Anniversary

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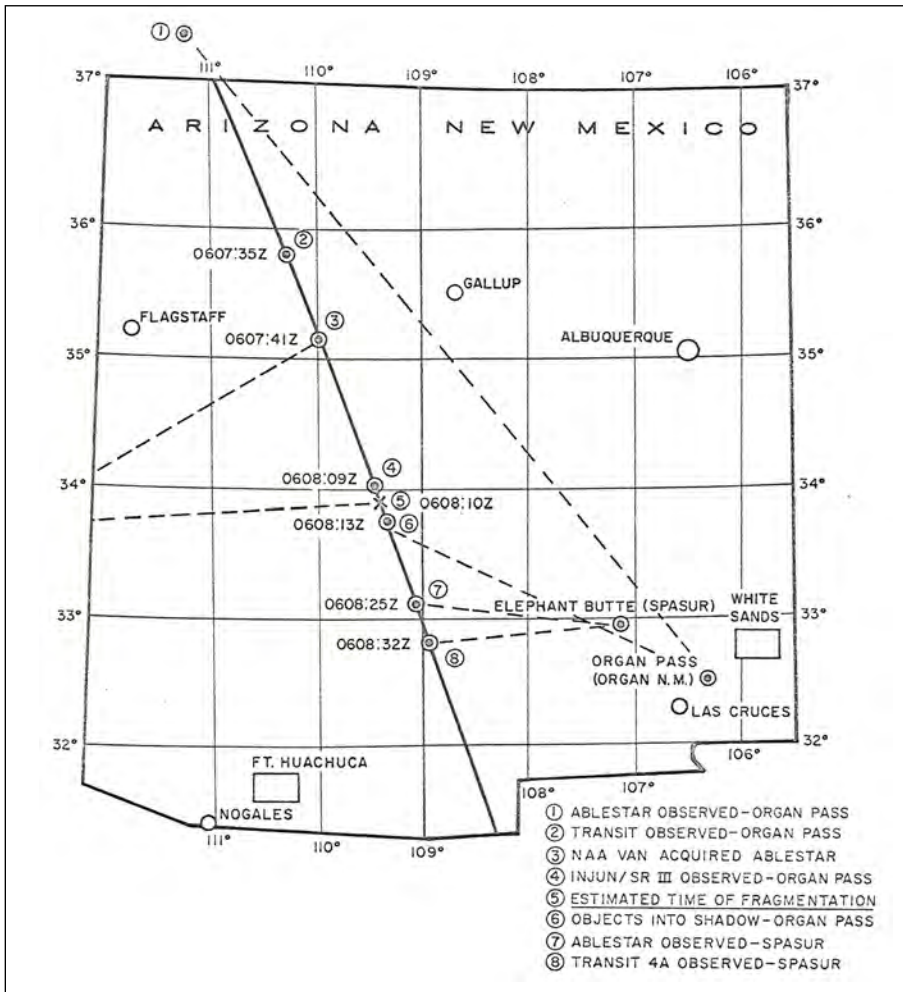


Figure 2. Trajectory and observations of the Ablestar stage on 29 June 1961.

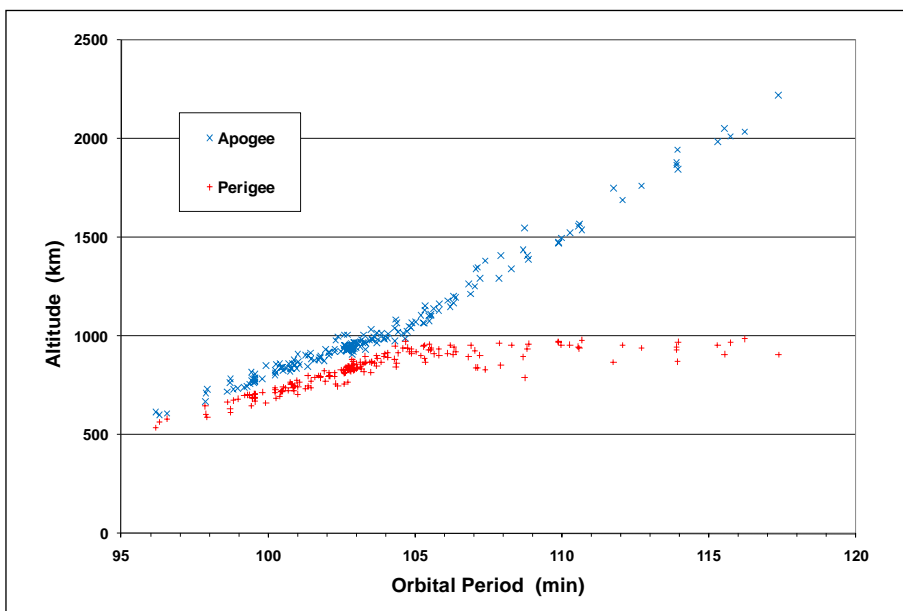


Figure 3. Distribution of Ablestar debris in 2011.

60 kg of fuel (inhibited red fuming nitric acid or IRFNA) and 41 kg of oxidizer (unsymmetrical dimethylhydrazine or UDMH), both under about 320 psia pressure (Figure 4). The stage also carried three helium pressurant tanks and a nitrogen-fed attitude control system.

Four means were found as possible triggers of the above mechanisms:

- a) Command destruct system initiation
- b) Propulsion system tankage or valve leakage or rupture
- c) Electrical/electronic system malfunction
- d) External heating or particle impact.

A detailed study of the command destruct system found it to be a highly improbable cause of the explosion. A minor meteor shower was underway during 27-30 June that year, but this, too, is viewed as an unlikely root cause, as is an electrical or electronic system failure.

This leaves the propulsion system itself as the likely reason for the breakup. Investigators noted that only a 30-40 psi decrease in the oxidizer tank pressure “would result in the inversion of oxidizer/fuel tank intermediate bulkhead. This in turn would result in rupture of the bulkhead and mixing of the residual hypergolic propellants.” The report went on to note five different ways for the oxidizer tank to lose pressure.

Perhaps the most telling finding was that on all previous Ablestar missions the fuel tank had been vented as part of the spacecraft separation process. However, due to concerns about possible contamination of venting fuel on the payloads, for the Transit 4A mission a separate helium-based retro system had been employed, and the fuel tank was left pressurized.

Since a single root cause could not be absolutely determined, a number of countermeasures were recommended for subsequent Ablestar missions, including the venting of the fuel tank and the disabling of the range safety system after release by the range safety officer.

Unfortunately, it was not until the 1980s and 1990s that passivation of all launch vehicle orbital stages became recognized as necessary to combat a number of intensive accidental explosions by stages from the U.S., Russia, China, India, the Ukraine, and the European Space Agency. Today, stage passivation

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## Fiftieth Anniversary

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measures are common and are explicitly recommended by several national space agencies, by the Inter-Agency Space Debris Coordination Committee (IADC), and by the United Nations. ♦

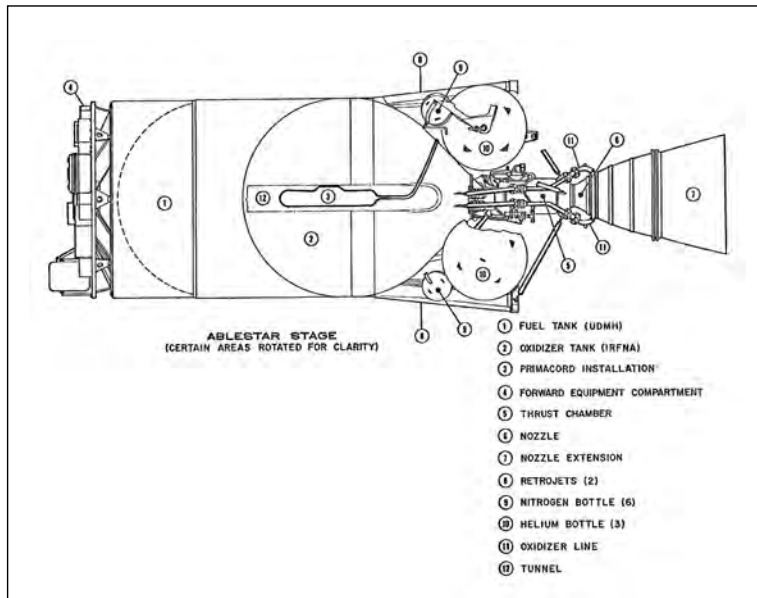


Figure 4. Diagram of Ablestar stage.

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## MMOD Impacts on ISS Airlock Shields

E. CHRISTIANSEN, C. ACHILLES, J. HYDE, K. ROSS, D. LEAR

This article describes the initial results from the inspection of two International Space Station (ISS) micrometeoroid and orbital debris (MMOD) shield panels that were removed from the U.S. airlock module. In April 2010, the panels were returned to Earth on STS-131 after almost 9 years of exposure to the MMOD environment, having been originally delivered with the airlock module on STS-104 in July 2001. Figure 1 shows the location of the two removed panels, which were on the zenith/aft surface of the large-diameter cylinder of the airlock. These panels are made of aluminum (6061-T6) and are each 1.3 m long, 0.84 m wide and 0.2 cm thick. In November 2009, the shield panels were removed from the airlock during STS-129 to allow a high-pressure gas carrier to be installed on the exterior of the airlock. After removal and prior to return on STS-131, the panels were stored on the ESP-2 external platform, which is installed adjacent to the airlock, on a nadir-facing surface (that is relatively well protected from MMOD impacts).

In January 2011, the MMOD inspection was performed by JSC personnel, who identified 58 impact craters that measured 0.3 mm diameter or more on the panel: 24 craters on the inboard panel and 34 craters



Figure 1. The ISS airlock module on right side, zenith view. Yellow dotted lines indicate the two exterior shield panels that were removed and returned to Earth for inspection. Panel 01-04B is the inboard panel and 02-04B is the outboard panel. The ISS velocity direction in this view is toward the top of the page.

on the outboard panel. Figure 2 illustrates features. Then, these samples were examined by Scanning Electron Microscope (SEM) x-ray from the crater lips of eight of the impact

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# MMOD Impacts

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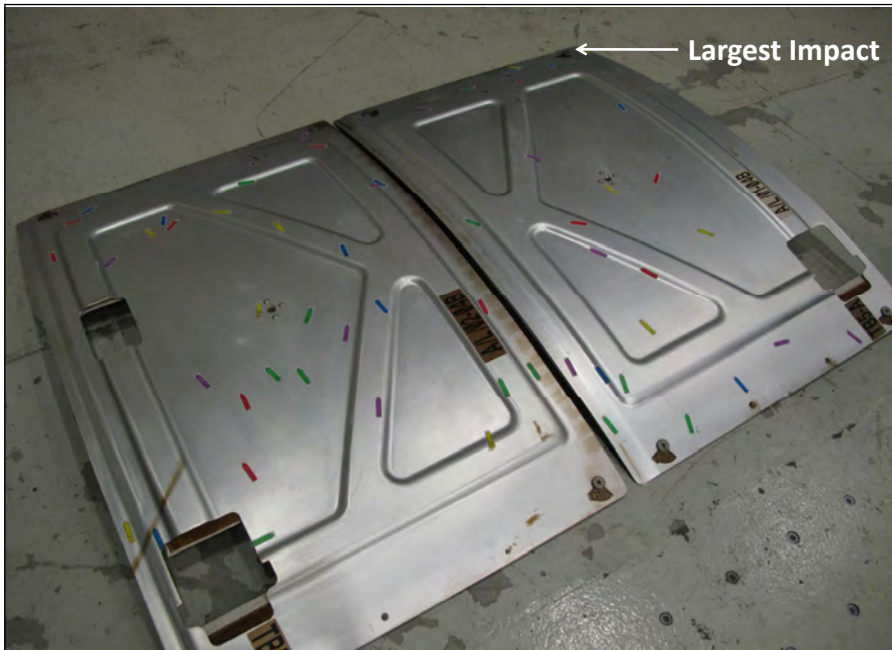


Figure 2. The locations of the 58 impact craters are indicated by colored arrows. The largest crater was found in the corner of the inboard panel (panel 01-04B).

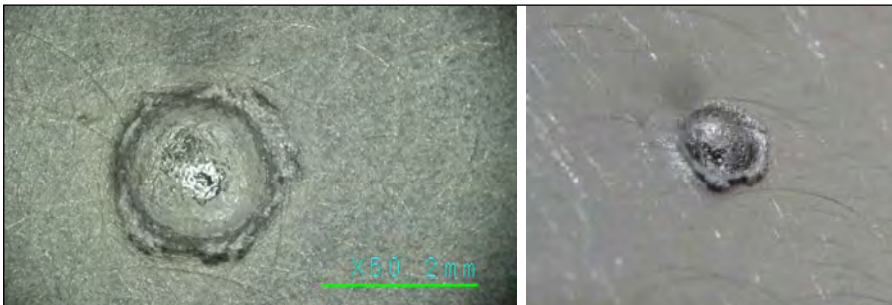


Figure 3. Top view (left) and oblique view (right) of the largest crater (1.8 mm diameter) found on the airlock panels.

analysis for projectile residues. The SEM x-ray results indicate the largest damage was produced by a silica rich particle, likely orbital debris (glass). The largest crater (Figure 3) was 1.8 mm in diameter and left a bump on the back side of the panel (the inside diameter of the crater was measured at the original surface of the panel). Figure 4 provides SEM images and spectra from this crater.

Table 1 presents results from the SEM x-ray analyses performed to-date, which indicate that six of the largest craters were likely caused by orbital debris containing silica-glass, Teflon, or a combination of both. These results indicate that high-speed debris from impacts on ISS solar arrays may have created some (or a majority) of the craters found on the airlock panels. Several of the craters showed marked ellipticity, indicating a highly-oblique impact, such as seen in Figure 5.

A detailed 3-dimensional scan of both panels has been performed by members of the Orbital Debris Program Office and will be reported at a later date. Further SEM/x-ray analysis is planned for selected craters. In addition, the Hypervelocity Impact Technology group will perform a comparison between predicted and observed craters using the BUMPER code and current MMOD environment models (MEM meteoroid model, and ORDEM2000 and ORDEM2010 debris models). ♦

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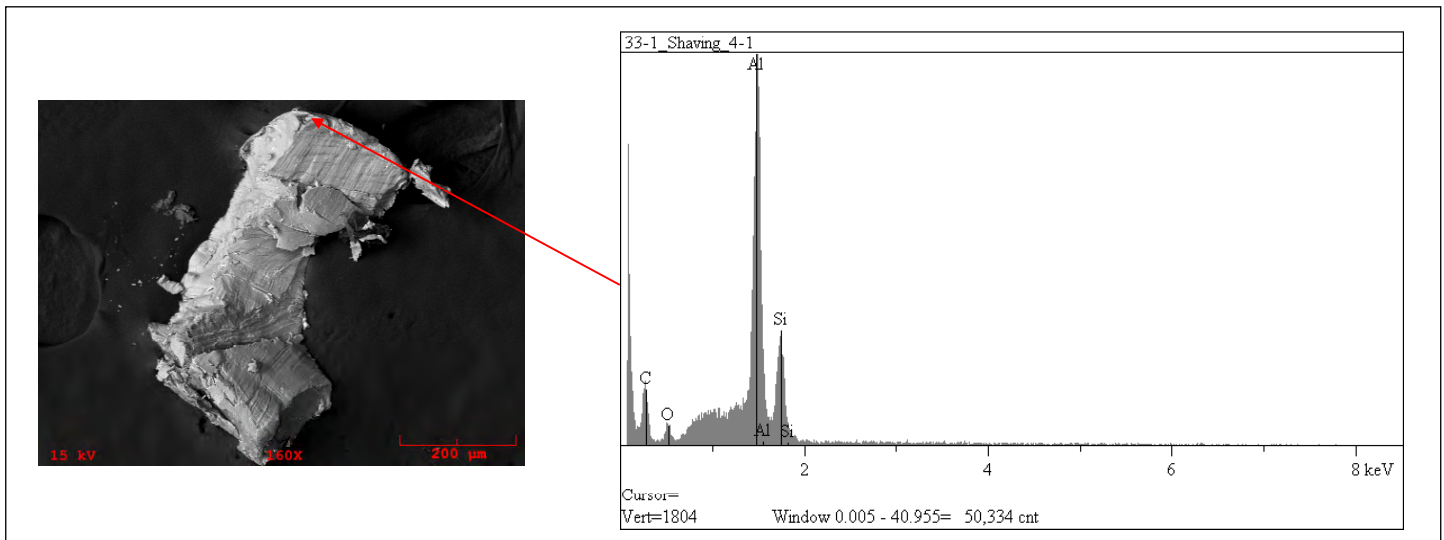


Figure 4. Traces of silica melt present on shavings of the crater lip taken from the largest impact crater.



# MMOD Impacts

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Table 1. Results of SEM X-ray Analysis of Crater Lips

Sample number	Crater length x width (mm)	SEM/X-ray results
33-1	1.8 x 1.8	OD: silica glass
33-2	1.1 x 1.0	OD: Fluorine-carbon (Teflon), silica glass, silicon (solar cell)
33-21	1.4 x 0.4	Unknown
34-2	1.3 x 1.1	Unknown
34-8	0.4 x 0.4	OD: Teflon, Silica glass
34-10	0.8 x 0.8	OD: Silica glass
34-11	0.9 x 0.9	OD: Silica glass
34-14	0.9 x 0.8	OD: Teflon



Figure 5. Non-circular crater found on the inboard panel (2.4 mm long x 0.9 mm wide).

## A Note on Active Debris Removal

J.-C. LIOU

The idea of orbital debris removal was first suggested almost 30 years ago [1]. Since that time, concepts for the removal of small or large orbital debris have been proposed by various groups on a regular basis. However, due to the tremendous technical challenges and the potential high cost, orbital debris removal has never been viewed as practical. In addition, there has been a lack of modeling tools to illustrate the need for debris removal and to quantify the necessary actions and the corresponding benefits for the environment. The two major breakups since 2007 and recent modeling analyses, confirming the instability of the debris population in low Earth orbit (LEO, the region below 2000 km altitude), have certainly re-energized discussions on the subject. The statement in the 2010 National Space Policy of the United States, to pursue research and technology development to remove on-orbit debris, also provides a top-level directive for NASA and DoD to engage in these activities [2].

Active debris removal (ADR) means to remove debris from orbit beyond the guidelines of the currently-adopted mitigation measures. The term ADR applies to all objects in orbit, including those that already exist in the current environment but lack the capability for deorbit per mitigation guidelines. The planning, technology development, and routine operations of ADR will require a significant amount of resources. Therefore, top-level mission objectives need to be established early to define a well-focused roadmap. Several key questions must be addressed at the beginning of

any ADR planning. They include (1) where is the most critical region for ADR, (2) what are the mission objectives, (3) which debris should be removed first, (4) what are the benefits to the environment, and finally, (5) how to carry out the operations. The answers to these questions will drive top-level requirements, necessary technology development, and implementation of ADR operations. They will also pave the way for a clear, efficient, and cost-effective effort to maximize the benefits to the environment and to better protect operational spacecraft in the future.

Recent environmental studies have indicated that the instability of the debris population in the upcoming centuries is only limited to LEO [3-5]. Although there is no atmospheric drag to clean up the environment in the medium Earth orbit (MEO) and geosynchronous orbit (GEO) regions, the buildup of debris there is progressing at a slower rate. Once the critical region for ADR is identified, mission objectives are needed to set the measures for success. Common mission objectives, such as maximizing the benefit-to-cost ratio and following practical mission constraints (in altitude, inclination, size, class, etc.) are always applicable to any ADR concepts. Specific mission objectives, on the other hand, are very diverse and will lead to very different forward paths. These objectives include, for example, controlling the LEO population growth, limiting collision activities, mitigating impact risks (damage, not necessarily catastrophic destruction) for selected spacecraft, or mitigating risks for human space activities. Once a specific mission objective is selected, it

needs to be further quantified (e.g., limiting the population growth or reducing mission-ending threats to some pre-set level) to better define the mission requirements.

Which debris objects should be removed first depends on the specific mission objective. The root cause of future LEO debris population growth will likely be accidental collisions involving large and massive intact objects (rocket bodies, R/Bs, or spacecraft) [6]. In general, they are at least several meters in size. If the ADR mission objective is to stabilize the debris population or to reduce major catastrophic collisions in the future environment, then these objects should be targeted for removal.

The LEO-crossing debris population below 10 cm roughly follows a power-law size distribution – meaning there are far more smaller debris than larger ones. This means the main mission-ending threat for operational spacecraft in the environment always comes from debris just above the threshold of the vehicle's impact protection shields. The critical debris size will vary between spacecraft, since they all have different configurations and shielding designs. For most operational spacecraft, however, any impact by debris between 5 mm and 1 cm is likely to cause mission-ending damage. The chances of similar damage diminish if the vehicle is impacted by smaller debris and increase if impacted by larger debris. Because of the power-law size distribution, debris in the 5-mm-to-1-cm regime represent about 80% of all objects larger than 5 mm. Therefore, if the ADR objective is to reduce the mission-ending threat for most operational spacecraft, then the

continued on page 8

# Active Debris Removal

continued from page 7

removal operations should focus on the 5-mm-to-1-cm debris.

In summary, for controlling future debris population growth or reducing collision activities in the environment, removal operations should focus on large (at least several meters in dimension) R/Bs or spacecraft. For reducing mission-ending threats to operational spacecraft, the focus should be on the 5-mm-to-1-cm debris. Targeting anything outside these two size regimes will not be an effective means to remediate the environment nor to mitigate mission-ending risks to operational spacecraft.

The technical challenges for removing large R/Bs or spacecraft have been discussed previously [7]. For removing 5-mm-to-1-cm debris, the challenges are different and could be even more demanding. The first challenge is due to the large number of targets in the environment. To remove any meaningful amount of these small debris, an area-time product, typically on the order of thousands of km<sup>2</sup>-year or more, will be needed for space-based collectors or removal systems. The second challenge for removing small debris is related to the highly dynamical nature of the particles in the environment. Small debris tend to have higher area-to-mass ratios (A/Ms). Those with perigees below about 1000 km altitude are subject

to strong atmospheric drag perturbations. This is illustrated in Figure 1, where a simulated evolution of the 5-mm-to-1-cm Cosmos 2251 debris between 2009 and 2019 is shown. The initial fragments were generated via the NASA Standard Breakup Model. Individual fragments were then propagated forward in time, including Earth's ( $J_2, J_3, J_4$ ) and solar-lunar gravitational perturbations, solar radiation pressure, and atmospheric drag. NOAA's solar flux F10.7 projection was combined with the Jacchia 1977 atmospheric model for the drag calculation.

What the curves in Figure 1 show is that, at any given altitude below 1000 km, the 5-mm-to-1-cm debris rapidly decay toward lower altitudes. At the same altitude, the region is also quickly replenished by small debris spiralling down from higher altitudes. The environment is highly dynamic and could have strong short-term (i.e., monthly to yearly) episodic variations.

A ground- or space-based laser system is another proposed concept for the removal of millimeter-to-centimeter-sized debris. Additional technical challenges for this approach are the power required for the system, tracking capability for small debris, and the pointing accuracy of the laser system. Because of the concern for space weapons, this concept also faces more non-technical issues.

The orbital debris problem has reached a critical point. The commonly-adopted mitigation measures will not be able to fully control the debris population growth in LEO. Collisions, such as the one between Iridium 33 and Cosmos 2251, will continue to occur, and so will impact damages to operational spacecraft. The trend will get worse unless more aggressive actions, such as ADR, are implemented in the future. As the international community gradually reaches a consensus on the need for ADR, the focus will shift from environment modeling to completely different challenges – technology development, systems engineering, and operations. A long-term strategic plan must be established first, before the community takes on these new challenges. Mission objectives must be clearly defined to determine the forward path. If the goal is to remediate the environment, then four critical “Cs” will be needed at the international level. The first “C” stands for the consensus on ADR. The second “C” is for cooperation – the removal targets may belong to a different country. The third “C” is for collaboration – it is highly unlikely that any single organization or country can accomplish the goal by itself. The last “C” stands for contributions – cost-sharing will be the key for using ADR to preserve the environment for future generations.

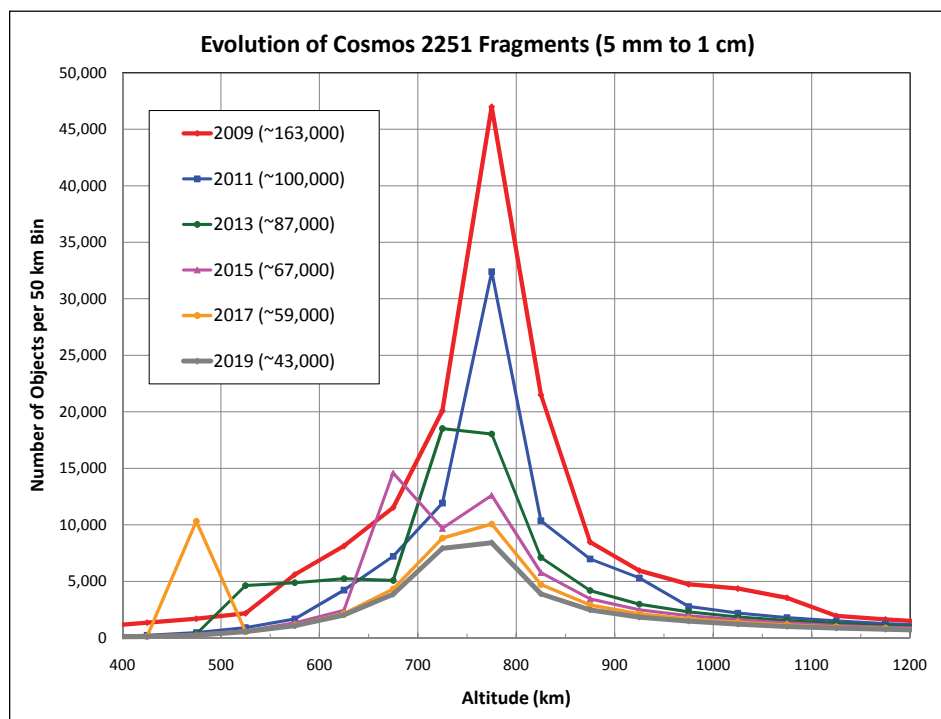


Figure 1. Altitude distributions of the simulated 5-mm-to-1-cm Cosmos 2251 fragments between 2009 and 2019. The number of remaining in-orbit objects at each snapshot is indicated in parenthesis.

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# MEETING REPORT

## The 28th International Symposium on Space Technology and Science (ISTS), 5-12 June 2011, Okinawa, Japan

The 28th International Symposium on Space Technology and Science (ISTS) was held in Okinawa, Japan, during the week of June 6<sup>th</sup>. The Symposium had a record turnout and the orbital debris sessions were well-attended. Professor H. Klinkrad of the European Space Agency (ESA) presented the first keynote speech on “The space debris environment – status and outlook” directly after the opening ceremony. A total of 35 papers were presented during 8 debris sessions. Various groups from Europe, Japan, Taiwan, and the U.S. reported on the new

and planned optical telescopes and advanced processing algorithms for debris observations and space situational awareness. Several in-situ measurement projects, including those utilizing small satellites, were also presented. Two hypervelocity impact experiment sessions focused on impact testing of satellite structures and new shielding materials. Conjunction assessment procedures and concepts for active debris removal, including technology development for electrodynamic tethers, were given during the safety, mitigation, and debris

removal sessions. Finally, a panel discussion on observations and characterization of space for orbital debris safety, with a special emphasis on international collaboration and Japanese contributions, was organized by JAXA’s Dr. H. Matsumoto and Dr. Y. Kitazawa, and moderated by Professor T. Hanada of the Kyushu University. Panel members consisted of representatives from ESA, NASA, the Air Force Research Laboratory, the U.S. Naval Research Laboratory, the Technische Universität Braunschweig, and the University of Bern. ♦

## UPCOMING MEETINGS

### 3-7 October 2011: The 62nd International Astronautical Congress (IAC), Cape Town, South Africa

The theme for the 62nd International Astronautical Congress (IAC) is “African Astronaissance” and the dates for the IAC have been chosen to coincide with World Space Week. The IAC will include a Space Debris Symposium to address various technical issues of space debris. Six sessions are planned for the Symposium: “Measurements,” “Modeling and Risk Analysis,” “Hypervelocity Impacts and Protection,” “Mitigation and Standards,” “Space Debris Detection and Characterization,” and “Removal and Legal Issues.” Additional information on the conference is available at: <<http://www.iac2011.com>>.

### 17-19 October 2011: The 5th International Association for the Advancement of Space Safety (IAASS) Conference, Versailles-Paris, France

The 5th IAASS Conference “A Safer Space for a Safer World” is an invitation to reflect and exchange information on a number of topics in space safety and sustainability of national and international interest. The conference is also a forum to promote mutual understanding, trust, and the widest possible international cooperation in such matters. The conference will include two orbital debris-related topics – “Space Debris Remediation” and “Spacecraft Re-entry Safety.” Additional information on the conference is available at: <<http://www.congrex.nl/11a03/>>.

## DAS 2.0 NOTICE

**Attention DAS 2.0 Users:** an updated solar flux table is available for use with DAS 2.0. Visit 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.

## SATELLITE BOX SCORE

(as of 06 July 2011, cataloged by the  
U.S. SPACE SURVEILLANCE NETWORK)

## INTERNATIONAL SPACE MISSIONS

1 April 2011– 30 June 2011

Country/ Organization	Payloads	Rocket Bodies & Debris	Total	International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
CHINA	105	3518	3623	2011-012A	SOYUZ-TMA 21	RUSSIA	381	396	51.6	1	0
CIS	1408	4667	6075	2011-013A	BEIDOU IGSO 3	CHINA	35701	35878	55.4	1	0
ESA	39	44	83	2011-014A	USA229	USA	NO ELEMS. AVAILABLE			0	1
FRANCE	49	435	484	2011-015A	RESOURCESAT 2	INDIA	819	826	98.8	1	0
INDIA	44	130	174	2011-015B	YOUTH SAT	INDIA	802	825	98.8		
JAPAN	114	69	183	2011-015C	XSAT	SINGAPORE/ TAIWAN	801	824	98.8		
USA	1144	3723	4867	2011-016A	INTELSAT NEW DAWN	INTELSAT	35779	35794	0.0	1	1
OTHER	493	112	605	2011-016B	YAHSAT 1A	UAE	35777	35796	0.0		
TOTAL	3396	12698	16094	2011-017A	PROGRESS-M 10M	RUSSIA	381	396	51.6	1	0
				2011-018A	MERIDIAN 4	RUSSIA	941	39415	62.9	1	0
				2011-019A	SBIRS GEO 1 (USA 230)	USA	35777	35796	6.4	1	0
				2011-020A	STS 134	USA	337	345	51.6	0	0
				2011-021A	TELSTAR 14R	CANADA	35784	35789	0.0	1	1
				2011-022A	GSAT 8	INDIA	35779	35792	0.1	1	1
				2011-022B	ST 2	SINGAPORE/ TAIWAN	35762	35811	0.0		
				2011-023A	SOYUZ-TMA 2M	RUSSIA	381	396	51.6	1	0
				2011-024A	SAC-D (AQUARIUS)	ARGENTINA	653	656	98.0	1	0
				2011-025A	RASAD 1	IRAN	191	202	55.7	1	0
				2011-026A	CHINASAT 10	CHINA	35775	35798	0.2	1	0
				2011-027A	PROGRESS-M 11M	RUSSIA	381	396	51.6	1	0
				2011-028A	COSMOS 2472	RUSSIA	216	334	81.4	1	0
				2011-029A	ORS-1	USA	400	410	40.0	1	0

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