National Aeronautics and Space Administration

Orbital Debris Quarterly News

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Inside...

A publication of the NASA Orbital Debris Program Office

International Space Station Avoids Debris from Old NASA Satellite

Once again in October 2010, the International Space Station (ISS) was forced to maneuver to avoid a potential collision with large orbital debris. Such maneuvers now occur about once per year. This time the threatening object was a piece of debris which had come off a 19-year-old NASA scientific spacecraft only one month earlier.

Since its decommissioning in late 2005, NASA's Upper Atmosphere Research Satellite (UARS) had been gradually falling back to Earth, and by late September 2010 the 5.7-metric-ton spacecraft was in an orbit of 335 km by 415 km with an inclination of 57.0 degrees, when the U.S. Space Surveillance Network (SSN) discovered that a fragment had separated from the vehicle. This was not unprecedented since four other pieces of debris had separated previously in November 2007 (Orbital Debris Quarterly News, January 2008, p. 1). The reasons for these releases remain unknown.

The new piece of debris, later cataloged as International Designator 1991-063G and U.S. Satellite Number 37195, was ejected with some force, resulting in an initial orbit of 375 km by 425 km, which was actually higher than the orbit of UARS. With its much greater area-to-mass ratio, the fragment began falling back to Earth much more rapidly than UARS itself, finally reentering the atmosphere on 4 November, after an orbital lifetime of only 6 weeks. For comparison, UARS is not expected to reenter until the summer of 2011.

Just 10 days before reentry

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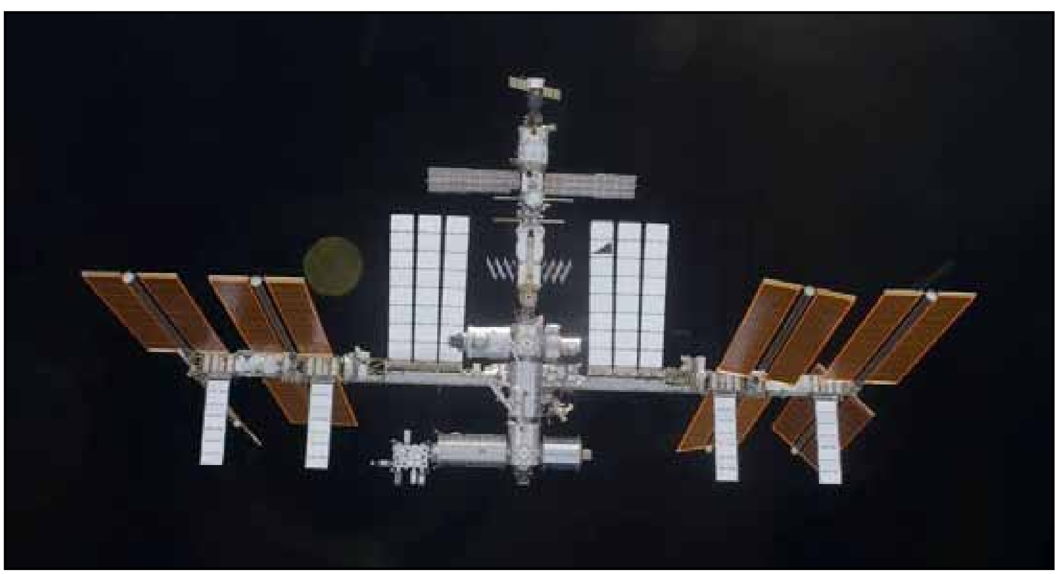

Figure 1. The International Space Station as seen from Space Shuttle Atlantis in May 2010.

ISS Avoids Debris

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Figure 2. The UARS satellite being deployed by Space Shuttle Discovery in 1991.

of the object, U.S. Strategic Command's Joint Space Operations Center (JSpOC) and NASA's Houston Mission Control Center calculated that the fragment from UARS would come unacceptably close to the ISS the following day, 26 October. The probability of collision was assessed to exceed 1 in 10,000, which is the nominal threshold for executing a collision avoidance maneuver. At the time, the orbit of the 370-metric-ton ISS was approximately 350 km by 360 km, and the orbit of the debris was 325 km by 360 km.

After updates of the respective orbits, new assessments confirmed a close approach which would violate standing safety protocols. Consequently, a decision was made to conduct a small, posigrade maneuver (i.e., + 0.4 m/s) a little more than 2 hours before the anticipated flyby. The collision avoidance maneuver was successfully performed by the Progress M-07M logistics vehicle which had docked at the aft port of the ISS Zvezda module on 12 September. ♦

New Satellite Fragmentations Add to Debris Population

The U.S. Space Surveillance Network (SSN) detected four new satellite fragmentations during October and November, three involving relatively young launch vehicle stage components and one associated with an old meteorological spacecraft. Fortunately, none of the events appears to have created large amounts of long-lived debris.

On 14 March 2008 the upper stage of a Russian Proton launch vehicle malfunctioned part way through the second of three planned burns designed to place a commercial spacecraft, AMC-14, into a geosynchronous transfer orbit. Although the spacecraft eventually limped into a geosynchronous orbit, albeit an inclined one, with its own propulsion system, the Briz-M upper stage was stranded in a highly elliptical orbit with a significant amount of residual propellant.

The stage (International Designator 2008-011B, U.S. Satellite Number 32709) remained dormant until 13 October 2010, more than two and a half years after launch, when it experienced an apparently minor fragmentation. At the time of the event, the stage was in an orbit of 645 km by 26,565 km with an inclination of 48.9 degrees. More than 30 debris from the stage have been provisionally identified by the SSN with orbital periods ranging from 430 to more than 540 minutes. However, to date only eight debris have been officially cataloged.

Figure 1. NOAA satellite of the TIROS-N class.

Due to the nature of this highly elliptical orbit, small debris are difficult for the SSN to detect and to track. In February 2007 another Briz-M, which had also failed in its delivery mission, exploded into an estimated 1000+ large fragments (*Orbital Debris Quarterly News*, April 2007, p.3), although only 92 debris have so far been officially cataloged.

Less than 3 weeks after the fragmentation of the Russian upper stage, a newly launched Chinese launch vehicle stage released dozens of debris for unknown reasons. Beidou G4, the latest addition to China's global navigation satellite system, was launched on 1 November by a Long March 3C rocket. The launch vehicle successfully delivered its payload into a geosynchronous transfer orbit of 160 km by 35,780 km with an inclination of 20.5 degrees, but within a few hours of launch the SSN detected more than 50 debris associated with the final stage of the vehicle (International Designator 2010-057B, U.S. Satellite Number 37211).

This event was reminiscent of the February 2007 breakup of a Long March 3 upper stage carrying another Beidou spacecraft. In that case the debris, which also were released very soon after launch, were initially believed to be associated with the spacecraft, which did encounter early system problems (*Orbital Debris Quarterly News*, April 2007, p.3). However, later

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New Satellite Fragmentations

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analysis confirmed the source of the debris was the final stage of the launch vehicle.

The third fragmentation event of the fourth quarter of 2010 originated from a 22-year-old U.S. meteorological satellite. Launched in late 1988, the NOAA-11 spacecraft (International Designator 1988-089A, U.S. Satellite Number 19531) operated for more than 15 years before being retired and decommissioned in June 2004. On 24 November 2010, two fragments were ejected from the spacecraft with moderate velocities, one to a higher orbit and one to a lower mean altitude.

At the time, NOAA-11 was in an orbit of 835 km by 850 km with an inclination of 98.8 degrees. The two debris were found in orbits of 815 km by 850 km and 840 km by 860 km and have been cataloged as U.S. Satellite Numbers 37241 and 37242, respectively. Three previous NOAA spacecraft (NOAA-6, NOAA-7, and NOAA-10) are known to have released small amounts of debris, ranging from three to eight, at least a dozen years after launch. All four NOAA spacecraft were part of the TIROS-N series and were launched between 1979 and 1988. The reason for these minor fragmentations remains unknown.

The final satellite breakup of the year occurred on 23 December and involved a piece of launch debris from Japan's IGS 4A and IGS 4B mission in February 2007. Officially known as 2007-005E (U.S. Satellite Number 30590), the object was the only one of 12 launch vehicle debris associated with the mission to still be in orbit nearly 4 years after launch. At the time of the event, the object was in an orbit of approximately 430 km by 440 km with an inclination of 97.3 degrees. The U.S. Space Surveillance Network initially detected less than 10 new debris, of which 3 were cataloged with U.S. satellite numbers 37261-37263 five days after the event. The nature of the object and, hence, the potential cause of its fragmentation, are unknown at this time. Due to the relatively low altitude of the breakup, the newly created debris will be short-lived. ♦

Disposal of Globalstar Satellites in 2010

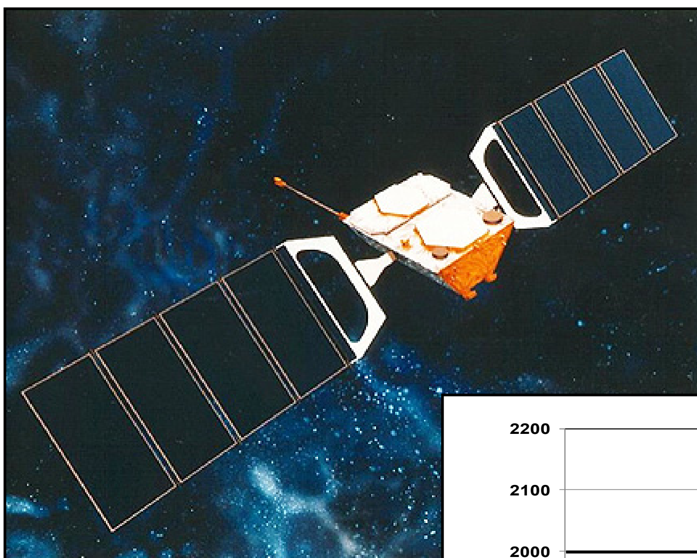

Figure 1. First generation Globalstar satellite.

The Globalstar communications satellite constellation operates in the upper portion of low Earth orbit (LEO) near 1415 km. From this altitude, the disposal of decommissioned spacecraft via atmospheric reentry is normally not attractive due to energy requirements. However, U.S. and international orbital debris mitigation guidelines, which call for satellites to vacate the LEO region after the end of mission, can be met by transferring the satellite to a disposal orbit beyond LEO, i.e., above 2000 km (*Orbital Debris Quarterly News*, January 2006, p. 5).

During 2010, four Globalstar satellites (Figure 1), which had been launched in 1999, initiated maneuvers to climb to disposal orbits near or above 2000 km. Such maneuvers are often conducted over a period of several months and can involve a temporary stay near 1515 km for engineering tests, as shown by Globalstar M49 in Figure 2. By the end of 2010, a total of 14 Globalstar spacecraft had been maneuvered into orbits above 1600 km. Each Globalstar spacecraft has a mass of just over one-half of a metric ton. ♦

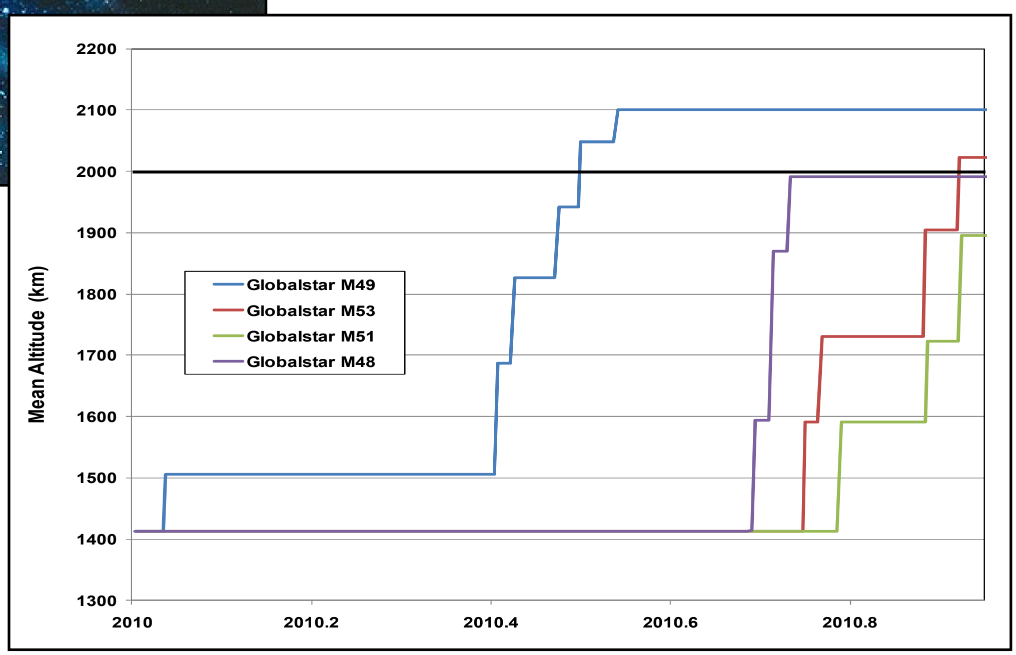

Figure 2. The disposal of four Globalstar satellites during 2010.

Canadian Space Agency Becomes Newest Member of IADC

The Inter-Agency Space Debris Coordination Committee (IADC) has accepted the Canadian Space Agency as the twelfth member of the renown organization. The IADC is the preeminent international body devoted to research across the entire spectrum of orbital debris issues, including environment characterization, modeling, protection, and mitigation.

The IADC was formally established in 1993 with four founding members: NASA, the Russian Space Agency, the European Space Agency, and a combined delegation from the three space agencies of Japan, since consolidated into the Japan Aerospace Exploration Agency (JAXA). Between 1996 and 2000, the space agencies of seven other nations joined the IADC: China, France, Germany, India, Italy, Ukraine, and the United Kingdom.

In addition to its internal cooperative activities, the IADC promotes a better public understanding of the orbital debris environment, its potential hazards, and the means to curtail its growth. The organization's website (www.iadc-online.org) offers numerous resource materials on orbital debris, as well as many technical reports and documents produced by the IADC. The IADC issued the first comprehensive international set of orbital debris mitigation guidelines in 2002 and provides technical information and assistance to the United Nation's Committee on the Peaceful Uses of Outer Space.

The 29th meeting of the IADC will be held in Berlin, Germany, during April 2011. ♦

NRC Review of the NASA MMOD Programs

At the request of the Office of Management and Budget (OMB) and the White House Office of Science and Technology Policy (OSTP), the Aeronautics and Space Engineering Board (ASEB) of the U.S. National Research Council (NRC) is conducting a study to assess NASA's orbital debris and micrometeoroid programs and provide recommendations on potential opportunities for enhancing the benefits these programs bring to the nation's activities in space.

The NRC has formed a 12-person committee chaired by orbital debris pioneer, Don Kessler. The committee's charter tasked them to review NASA's existing efforts, policies, and organization with regards to orbital debris and micrometeoroids, including efforts in the following areas: modeling and simulation, detection and monitoring, protection, mitigation, reentry, collision assessment risk analysis and launch collision avoidance, interagency cooperation, international cooperation, and cooperation with the commercial space industry.

Further, the committee was asked to assess whether NASA should initiate work in any new orbital debris or micrometeoroid areas and to recommend whether NASA should increase or decrease efforts in, or change the focus of, any of its current orbital debris or micrometeoroid efforts to improve the programs' abilities to serve NASA and other national and international activities.

The committee's first meeting was held in Washington, D.C., 13-15 December 2010. The second meeting is scheduled for 19-21 January 2011, in Houston. The committee is expected to complete its review this Spring. ♦

PROJECT REVIEW

MMOD damage to the ISS Solar Array Guidewire

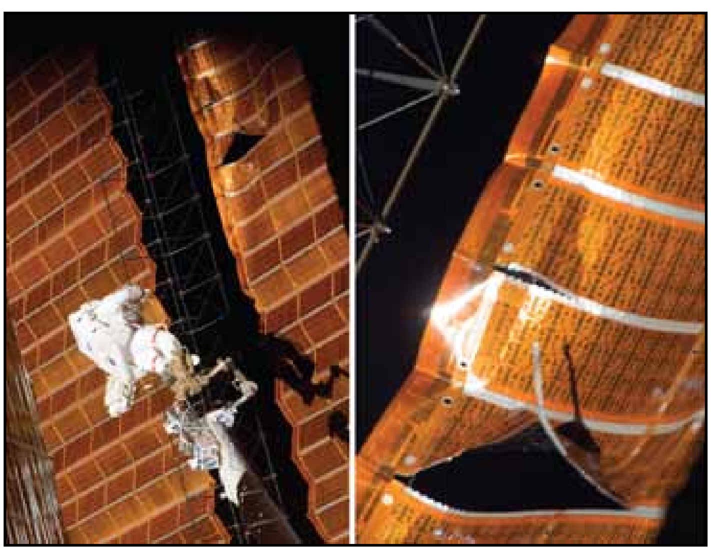

Figure 1. Tears in ISS P6 solar array wing 4B after attempt at re-deployment during STS-120 mission.

D. ROSS, E. CHRISTIANSEN, AND D. LEAR

During the STS-120 mission in 2007, astronauts moved the P6 solar photovoltaic power module (P6) from its original location on the Z1 truss (where it generated power for almost 7 years) to its permanent location on the port outboard truss of the International Space Station (ISS). The P6 contains two solar array wings (SAW), referred to as SAW 2B and SAW 4B. The P6 transfer operation consisted of first retracting each solar array wing, then moving the P6 module from the Z1 truss and reinstalling it at its permanent location, and finally, redeploying the solar array wings to generate power. During the SAW 4B deployment operation, the solar array began to tear in two places and the operation was halted at about 90% deployment. The STS-120 crew and ground control determined that a guidewire had frayed and snagged on a grommet, causing two tears in the solar array that measured approximately 30 cm and almost 90 cm, respectively (Figure 1). During extravehicular activity (EVA) #4, astronaut Scott Parazynski cut the snagged wire from SAW 4B. The EVA crew also installed reinforcing straps and fully extended the solar array. The piece of guidewire that was removed was returned to the ground

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MMOD Damage

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for analysis.

The frayed end of the guidewire was examined by scanning electron microscopes (SEM) at the JSC Astromaterials Research and Exploration Science (ARES) Directorate by personnel of the Hypervelocity Impact Technology (HVIT) Team. Seven individual wires that had been broken at the frayed end (Figures 2-3) were identified. Near the broken ends of three wires, the SEM examination discovered a large amount of material that appeared to have been melted at one time (Figure 4). The presence of melt is a clear indication that the damage to these three wires was caused by micrometeoroid or orbital debris (MMOD) impact. (MMOD particles typically impact at high speed and release a large amount of energy, resulting in the displacement of target material with a mass 10 to 100 times the projectile mass, due to melting and plastic flow local to the impact site.)

Other wires in the bundle appear to have been broken by mechanical action. A likely scenario that explains the observed guidewire damage is that MMOD impact broke a few of the wires, which allowed the guidewire to snag in a SAW grommet during deployment. Subsequently, as the process of deployment continued with a snagged guidewire, additional wires were sheared as they were pulled against the grommet.

An effort was made to identify the source of the impact damage. The SEM is equipped with a narrow focus electron microprobe and energy dispersive x-ray spectrometer to detect the elemental composition of materials found in the impact zone. The wire is composed of FeCrNi-rich stainless steel, and these elements are present in all spectra. Also, carbon-rich particles are abundant on all of the wires, likely from the plastic bag containing the sample (i.e., contamination). However, several foreign particles with composition differing from the stainless steel wire material were detected in the area of the wires that had considerable melt. Bismuth metal, gold-copper-sulfur, gold-silver-copper, lanthanum-cerium, antimony-sulfur and tungsten-sulfur bearing particles were identified (Figures 5-6). The composition of these particles suggests the possibility that an orbital debris impact was responsible for breaking wires within the guidewire bundle. No evidence of micrometeoroid impact was found. ♦

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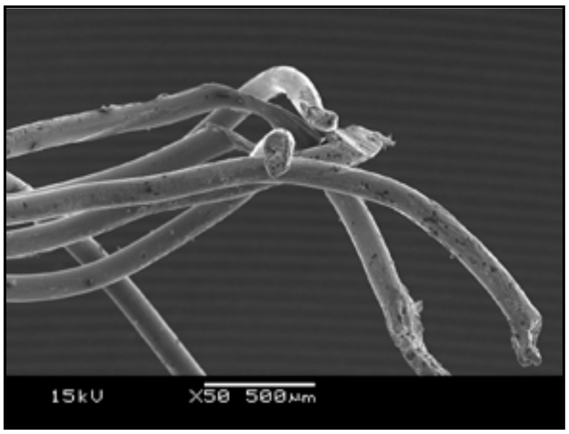

Figure 2. Frayed end of 4B SAW guidewire. Wires at bottom and in lower right-hand corner exhibited melt near ends.

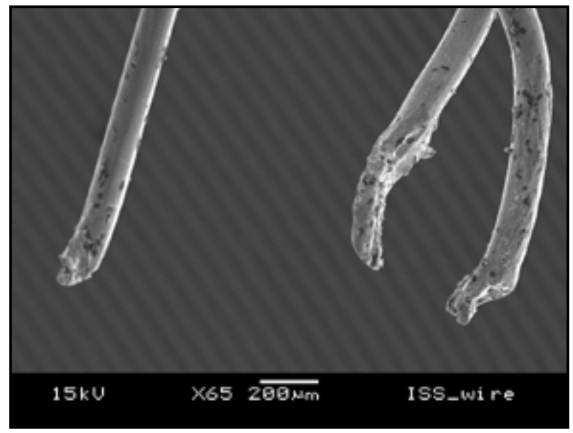

Figure 3. Another three wires exhibit melt near broken ends.

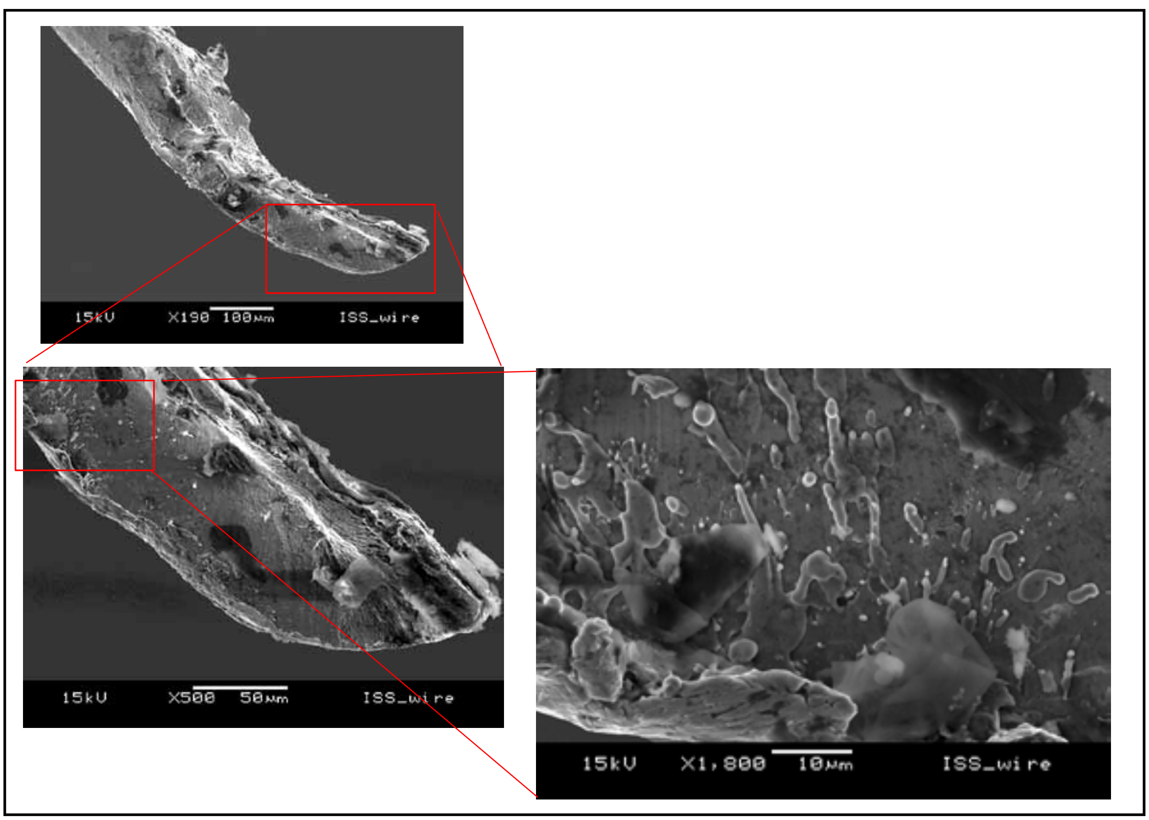

Figure 4. Evidence of melting is clearly visible in the lower right hand image. Molten droplets of steel have migrated across the surface, leaving trails that were quenched.

MMOD Damage

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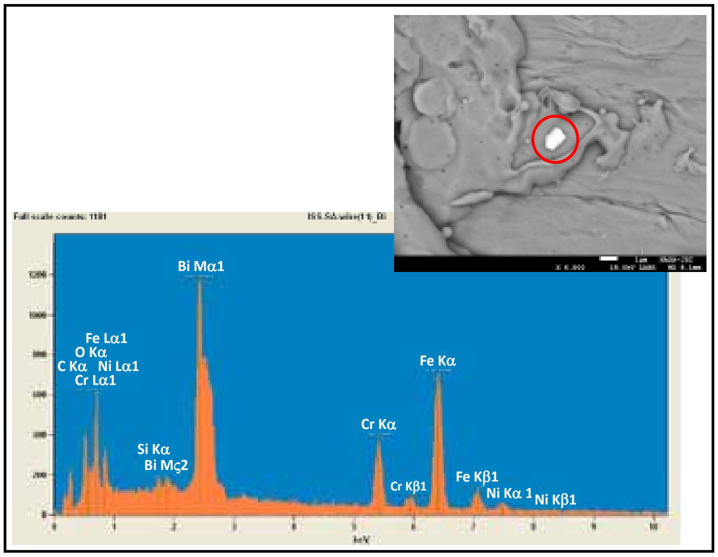

Figure 5. Example of a bismuth-rich particle on melted zone on steel wire. Fe, Cr and Ni peaks are from underlying wire.

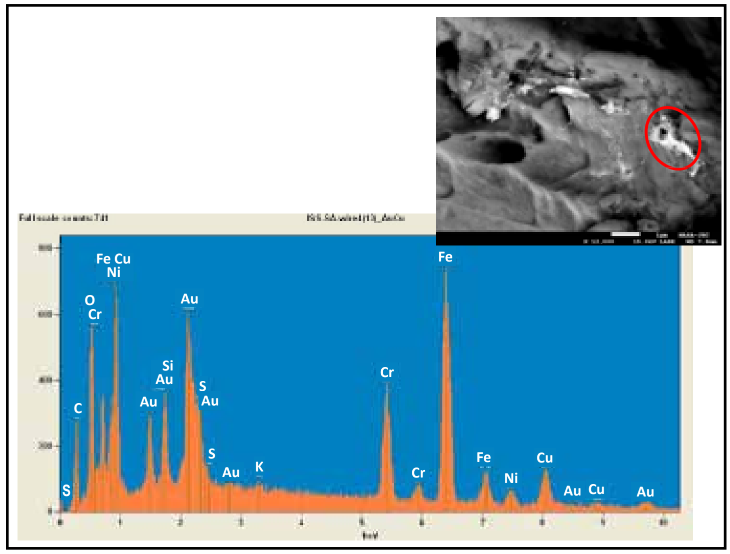

Figure 6. Example of a gold-rich particle.

Challenges in Interpreting HST Impact Features

P. ANZ-MEADOR

"It appeared as if the ZOT paint acted like a meteoroid bumper, shattering the impacting particle before it hit the aluminum plate, and allowing the fragments to disperse somewhat. The surprising thing is that the fragments could disperse so much in such a short distance - the thickness of the paint."

Thus Donald Humes described the apparent effect of a Zinc Ortho-Titanate (ZOT) paint on impact features, observed by him and Bill Kinard, on the Hubble Space Telescope (HST) Wide Field Planetary Camera (WFPC) -1 radiator following its return from the first servicing mission in 1993. This somewhat surprising effect, also observed in the majority of impact features on the WFPC-2 radiator, complicates the interpretation of the MMOD flux. Whereas the characterization of impact features by depth and diameter on unpainted surfaces has been long established, the mitigation provided by the painted layer presented a challenge to further analysis of the WFPC-2 features; a literature search revealed no prior characterization of painted or coated surfaces.

To address that challenge the NASA Orbital Debris Program Office, working in conjunction with the NASA Johnson Space Center's (JSC) Hypervelocity Impact Technology (HVIT) team and collaborators at NASA Goddard Space Flight Center, sponsored a series of calibration shots at the NASA White Sands Test Facility (WSTF) 0.17 cal gun range. This effort required the following activities: the production and painting of test coupons in a manner similar to the actual radiator, as well as a post-painting vacuum "bake-out" treatment to artificially age the paint by forced outgassing; the determination of the test matrix parameters projectile diameter and material (mass density), impact speed, and impact angle, so as to enable both an adequate characterization of the impact by projectile and impact geometry and support hydrocode modeling to fill in and extend the applicability of the calibration shots; the selection of suitable projectiles; logistics; and an analysis of feature characteristics upon return of the coupons to JSC.

Observed WFPC-2 impacts indicated a majority of impactors broke up in the weathered YB-71 paint layer, estimated to be between 4 and 6 mil (approximately 100-150 μm thick).[1] Given the uncertainty in the paint layer's behavior when impacted, a necessary consideration in attempting to mimic the radiator's observed features was the assembly of a projectile ensemble consisting of well characterized, spherical particles as small as 100 μm in diameter. Since these sizes were below the HVIT stocks for some material types, commercial spheres, dust, and powders were obtained, sieved by standard size range in the JSC Gun Lab, and manually sorted using the Keyence VHX-600 digital microscope.

Previous analyses of impact crater residues identified as being orbital debris indicated that there is a spread in densities ranging from low density plastics and computer board-type materials to high density steels, copper, and silver.[2] Density is an important parameter for this series of tests because damage equations are directly proportional to mass density.[3] In order to represent the observed variation in density, the projectile catalog was expanded to incorporate not only the usual Al (2.796 g/cm^3), Al_2O_3 (4 g/cm^3), steel (7.86 g/cm^3), and soda lime glass (2.45 g/cm^3) projectiles, but also polyethylene plastic (1 g/cm^3), Ni (8.03 g/cm^3), and Pb-Sn solder (8.4 g/cm^3) spheres and spheroids. Copper (8.93 g/cm^3) dust projectiles were also obtained, but were not used due to the difficulty in sorting out projectiles of approximately spherical shape — in the end, a suitable ensemble of reasonably spherical particles could not be assembled within the program's time constraint.

This difficulty was also present in sorting the Al, steel, and Ni particles due to the manner in which they are produced — typically by a plasma spray technique. In the case of the solder and plastic projectiles, the manufacturing process itself produced particles of negligible eccentricity, so these were immediately usable in the gun range.

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Challenges

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Following the solder shots, the WSTF 0.17 cal gun range was thoroughly cleaned to ensure no remnant Pb contamination. Paint residues represent a significant fraction of all identified constituents in STS window (40.7%) and radiator (47.5%) impacts. A feasibility study indicated that paint projectiles could be formed using a nebulizer spray technique; however, this was not pursued due to time constraints and concerns about the survivability of such projectiles when accelerated in the gun range. Whether or not a spherical paint projectile would be representative of paint debris on orbit, in any case, was not addressed.

Impact parameters, in addition to projectile density and diameter, were also selected by impact angle θ (measured with respect to the impact coupon's surface normal unit vector) and speed. A typical impact angle of 45° was used for the majority of shots, but angles of 0° (normal incidence) and 70° were also used to observe variation in damage equation cos θ effects. Measured impact speeds ranged from 2.7 km/s to near the range's maximum at 8.2 km/s.

The series of 68 shots, of which 62 successfully impacted the test surface, concentrated on aluminum test coupons painted with the prototypical YB-71 ZOT paint. However, the test series also featured seven shots into a representative multi-layer insulation (MLI) face sheet and three into a silver-Teflon taped surface. The MLI shots are to support projectile interpretation efforts associated with the recent survey of the HST Bay 5 MLI blanket performed at JSC (Orbital Debris Quarterly News, April 2010, p. 5-6), while the latter shots are intended to support interpretation of impact features observed on the HST aft bus structure by the JSC Image Science & Analysis Group (ISAG).

As Figure 1 demonstrates, test impact features comparable with those features observed on the WFPC-2 were obtained. Other test coupon shots resulted in a concentric area of paint spallation, similar to that displayed by the larger impacts. Figure 2a, an MLI shot, also displays features similar to those observed in the Bay 5 inspection, namely the central through hole, a melted annulus, and an area in which the transparent top layer has crazed. Figure 2b appears typical of many impact features observed on orbit by astronauts, and by the subsequent ISAG analysis. In general, impact phenomenology for all three types of surface tested appear similar to actual, observed behavior, thus providing a foundation for discerning fundamental relationships between surface and projectile characteristics.

As of this writing, microscopic inspection of the impact features is nearing completion. Once done, the feature data will be used to determine relevant ballistic limit equations for all three types of surface. These results, coupled with HST orientation information and environmental modeling, will be used to interpret the MMOD features resident on the WFPC-2 radiator and other HST surface.

1. Opiela, J., Liou, J.-C., and Anz-Meador, P. "Data Collected During the Post-Flight Survey of Micrometeoroid and Orbital Debris Impact Features on the Hubble Wide Field Planetary Camera 2." Presented at the 2010 IAC conference, Prague, October 2010.

2. As cataloged in the HVIT Shuttle Impact database, **4**, 6 November 2009.

3. Klinkrad, H. and Stokes, H. "Hypervelocity Impact Damage Assessment and Protection Techniques." *Space Debris: Models and Risk Analysis*, p. 205-8, (2006). ♦

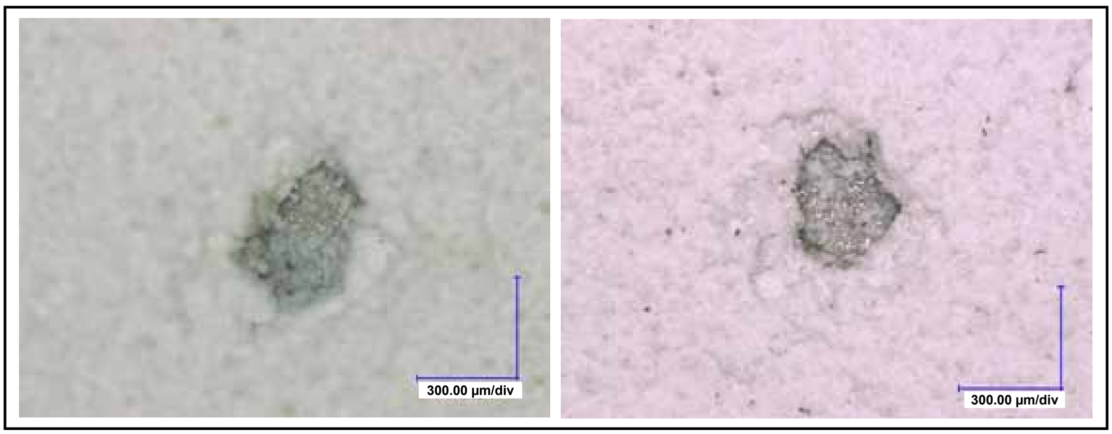

Figure 1. An impact feature observed on the WFPC-2 radiator (left) and on an impact coupon (right). In the latter case, the projectile was a 100 µm Aluminum 2017-T4 sphere impacting the coupon at 5.32 km/s at an angle of 45°.

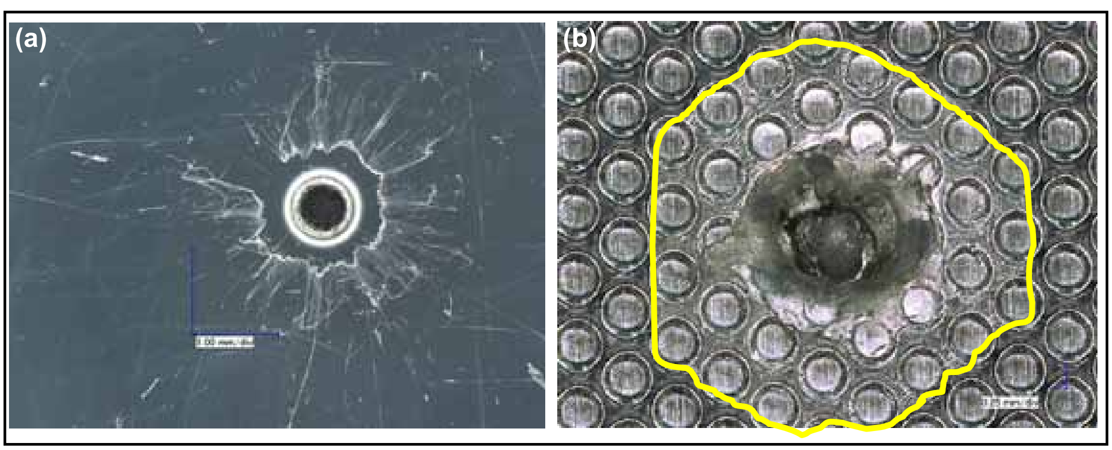

Figure 2a. (left) A calibration shot into the MLI face sheet. Characteristics of the MLI were 127 µm Teflon FEP with Silver/Inconel coating, while the projectile was a 250 µm soda lime glass sphere impacting normally at 4.2 km/s. Figure 2b (right) depicts the crater formed by a 200 µm Nickel sphere striking the taped coupon at a speed of 3.8 km/s and an angle of 45°. The superimposed yellow line indicates the approximate extent of a zone in which the tape has apparently delaminated from the Al substrate.

MEETING REPORTS

2010 USSTRATCOM Space Symposium, 2-3 November 2010, Omaha, Nebraska

At U.S. Strategic Command's (USSTRATCOM) 2010 Space Symposium during 2-3 November, orbital debris was the subject of the first panel session. Held in Omaha, Nebraska, near the headquarters of USSTRATCOM, each year the symposium brings together senior leaders and the dedicated men and women who support the U.S. Space Surveillance Network and the many space systems vital to the United States.

Following the keynote address by Gen. Kevin P. Chilton, Commander of USSTRATCOM, a panel entitled "Space Situational Awareness – Debris Management and Mitigation Strategies" addressed the major issues associated with orbital debris today. The panel members included Mr. Earl White of DoD's Space Protection Program, Dr. Heiner Klinkrad of the European Space Agency's Space Debris Office, Dr. Darren McKnight of Integrity Applications Incorporated, and Dr. William Ailor of the Aerospace Corporation. The panel was moderated by Nicholas Johnson of the NASA Orbital Debris Program Office.

The primary topics covered were the congested space environment and necessary operational responses; orbital debris status and outlook; orbital debris management and mitigation; and orbital debris removal. ♦

UPCOMING MEETINGS

13-17 February 2011: The 21st American Astronautical Society (AAS)/American Institute of Aeronautics and Astronautics (AIAA) Space Flight Mechanics Meeting, New Orleans, Louisiana

The 21st meeting of this series will include 25 sessions on topics related to space flight mechanics and astrodynamics, including trajectory and orbit determination; spacecraft guidance, navigation, and control; rendezvous and proximity operations; and lunar and asteroid mission design. A space surveillance session and two orbital debris sessions, "Orbital Debris and Space Environment" and "Space Debris Removal," are also included in the program. More information about the meeting can be found at: <http://www.space-flight.org/docs/2011_winter/2011_winter.html>.

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

The main theme of the 2011 ISTS is "Exploring Humans, Earth, and Space." The Symposium will include several plenary sessions with invited speakers, panel discussions on human exploration in space, and 17 technical sessions covering topics ranging from propulsion; astrodynamics; navigation, guidance, and control; space utilization; satellite communications; explorations; and space environment and debris. Additional information about the Symposium is available at: <http://www.ists.or.jp/2011/>.

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

The theme for the 62nd International Astronautical Congress is "African Astronaissance." The dates have been chosen to coincide with World Space Week. The Congress will include a Space Debris Symposium to address various technical issues of space debris. Five sessions are planned for the Symposium: "Measurements," "Modeling and Risk Analysis," "Hypervelocity Impacts and Protection," "Mitigation and Standards," 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/>.

Read the United Nations' "Ten Stories the World Should Hear More About: Space Debris" at <http://www.un.org/en/events/tenstories/08/spacedebris.shtml>.

INTERNATIONAL SPACE MISSIONS
1 October 2010 – 31 December 2010

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2010-050A	CHANG'E 2	CHINA	LUNAR ORBIT			1	0
2010-051A	SJ-6G	CHINA	586	607	97.8	1	1
2010-051B	SJ-6H	CHINA	587	605	97.7		
2010-052A	SOYUZ-TMA 1M	RUSSIA	348	355	51.6	1	0
2010-053A	XM-5	USA	35780	35794	0.1	1	1
2010-045A	GLOBALSTAR M079	GLOBALSTAR	1000	1059	52.0	1	0
2010-045B	GLOBALSTAR M074	GLOBALSTAR	996	1011	52.0		
2010-045C	GLOBALSTAR M076	GLOBALSTAR	1003	1014	52.0		
2010-045D	GLOBALSTAR M077	GLOBALSTAR	951	993	52.0		
2010-045E	GLOBALSTAR M075	GLOBALSTAR	1413	1414	52.0		
2010-045F	GLOBALSTAR M073	GLOBALSTAR	956	1003	52.0		
2010-055A	PROGRESS-M 08M	RUSSIA	348	355	51.6	1	0
2010-056A	EUTELSAT W3B	EUTELSAT	256	35775	1.8	1	1
2010-056B	BSAT 3B	JAPAN	35771	35802	0.1		
2010-057A	BEIDOU G4	CHINA	35781	35792	1.7	1	0
2010-058A	MERIDIAN 3	RUSSIA	957	39392	62.8	1	0
2010-059A	FENGYUN 3B	CHINA	825	828	98.7	1	0
2010-060A	SKYMED 4	ITALY	622	623	97.9	1	0
2010-061A	SKYTERRA 1	USA	35772	35801	6.0	1	1
2010-062A	STPSAT 2 (USA 217)	USA	NO ELEMS. AVAILABLE			2	2
2010-062B	RAX (USA 218)	USA	NO ELEMS. AVAILABLE				
2010-062C	O/OREOS (USA 219)	USA	NO ELEMS. AVAILABLE				
2010-062D	RASTSAT-HSV01 (USA 220)	USA	NO ELEMS. AVAILABLE				
2010-062E	FALCONSAT 5 (USA 221)	USA	NO ELEMS. AVAILABLE				
2010-062F	FAST 1 (USA 222)	USA	NO ELEMS. AVAILABLE				
2010-063A	USA 223	USA	NO ELEMS. AVAILABLE			1	0
2010-064A	CHINASAT 20A	CHINA	35777	35795	0.5	1	0
2010-065A	HYLAS 1	UK	35635	35834	0.0	1	1
2010-065B	INTELSAT 17	INTELSAT	35768	35805	0.0		
2010-066A	DRAGON C1	USA	281	306	34.5	1	0
2010-066B	QBX2	USA	249	270	34.5		
2010-066C	SMDC ONE	USA	240	261	34.5		
2010-066D	PERSEUS 003	USA	179	190	34.5		
2010-066E	PERSEUS 001	USA	176	183	34.5		
2010-066F	QBX1	USA	220	240	34.5		
2010-066G	PERSEUS 002	USA	183	193	34.5		
2010-066H	PERSEUS 000	USA	180	190	34.5		
2010-066J	MAYFLOWER	USA	179	194	34.5		
2010-067A	SOYUZ-TMA 20	RUSSIA	348	355	51.6	1	0
2010-068A	BEIDOU IGSO 2	CHINA	35719	35855	55.2	1	0
2010-069A	KA-SAT	EUTELSAT	EN ROUTE TO GEO			1	1
2010-070A	HISPASAT 1E	SPAIN	35723	35752	0.1	1	1
2010-070B	KOREASAT 6	SOUTH KOREA	EN ROUTE TO GEO				

SATELLITE BOX SCORE
(as of 5 January 2011, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	100	3388	3488
CIS	1406	4646	6052
ESA	39	44	83
FRANCE	49	431	480
INDIA	41	132	173
JAPAN	114	75	189
USA	1142	3691	4833
OTHER	489	112	601
TOTAL	3380	12519	15899

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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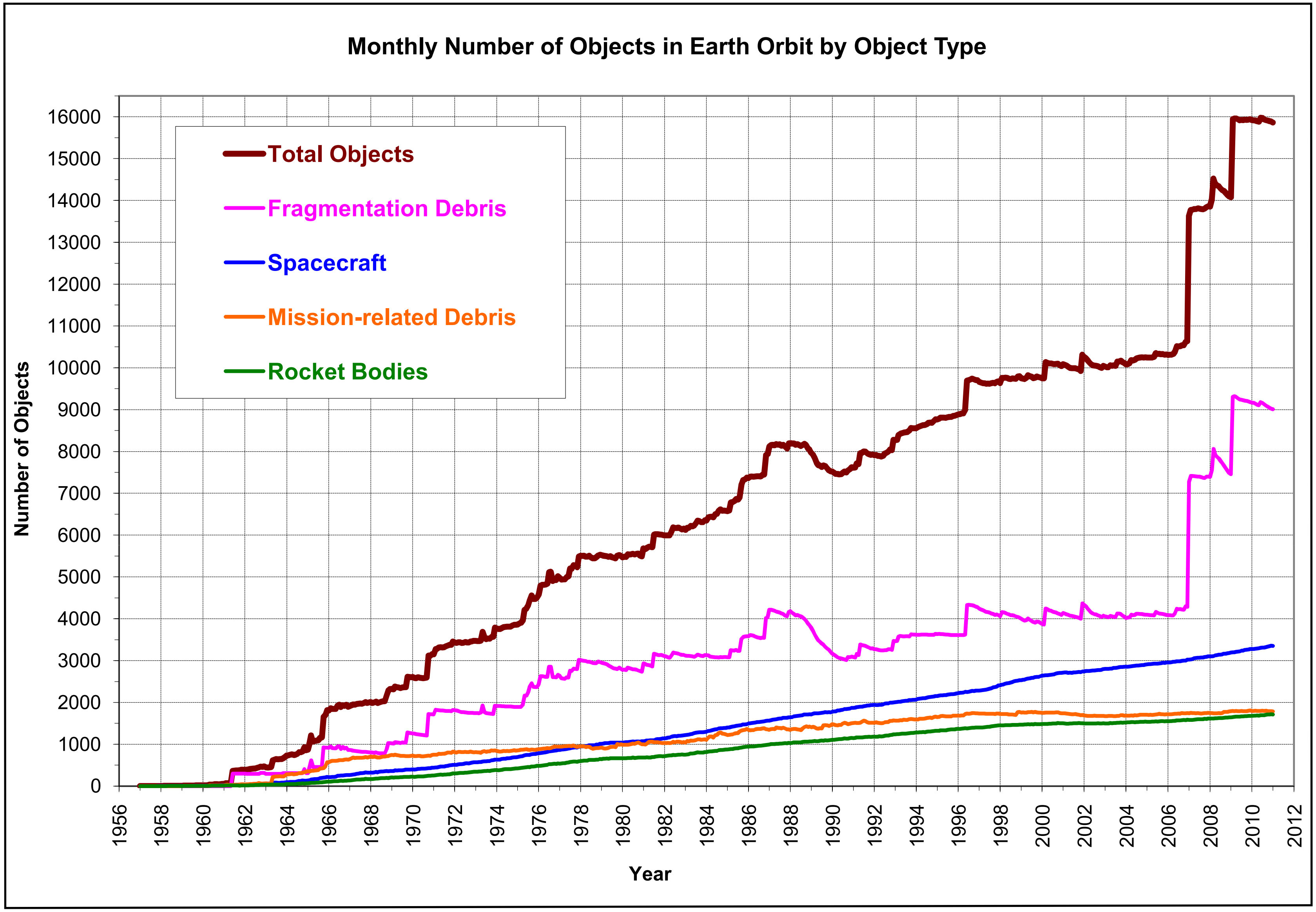

Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission.