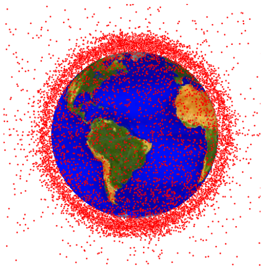
National Aeronautics and Space Administration

Orbital Debris
Quarterly News

Volume 19, Issue 3
July 2015

Inside...



A publication of
the NASA Orbital
Debris Program Office

International Space Station Performs Two Debris Avoidance Maneuvers and a Shelter-in-Place

The International Space Station (ISS) performed two debris avoidance maneuvers this quarter. These are the first such maneuvers this year.

The first maneuver was performed at 05:22 GMT on 23 April. The Pre-determined Debris Avoidance Maneuver (PDAM) was performed to avoid a close approach from orbital debris originating from the METEOR 2-5 satellite (International Designator 1979-095AD, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog number 36888). At the time of the encounter, the rapidly-decaying debris object was in an approximately 423 x 398 km, 81.12° orbit. The 2-min-20-sec burn executed by thrusters on Progress 58 produced a delta-v of 0.3 m/sec. The burn raised the ISS orbit by about half a kilometer. The object is estimated to be approximately 8 cm in characteristic length and displays an estimated area-to-mass ratio of approximately 0.225 m^2/kg; it has since decayed to an altitude below the ISS.

A second PDAM was performed to avoid a close conjunction with a discarded Minotaur I fourth stage (Figures 1 and 2; 2013-064AF, SSN# 39409) used to launch the STPSat-3 satellite along with 28 CubeSats. At the time of the encounter, the upper stage was in an approximately 413 x 397 km, 40.49° orbit. The 0.3 m/sec maneuver was executed on 8 June at 19:58 GMT using thrusters from the same Progress as the earlier PDAM.

These maneuvers were the 22nd and 23rd ISS maneuvers since 1999.

A close conjunction from another debris fragment from METEOR 2-5 (1979-095BD, SSN# 36912) occurred on 16 July at 12:01 GMT. Two observations of the debris occurred early in the morning of 16 July that provided a risk of collision which exceeded the red threshold for maneuvering the ISS away from the conjunction. However, there was not enough time to safely execute a PDAM. Instead, the crew of the ISS executed a "Shelter-in-Place" procedure where they retreated to the Soyuz spacecraft from which they could return to Earth if the ISS had been breached. This was the fourth

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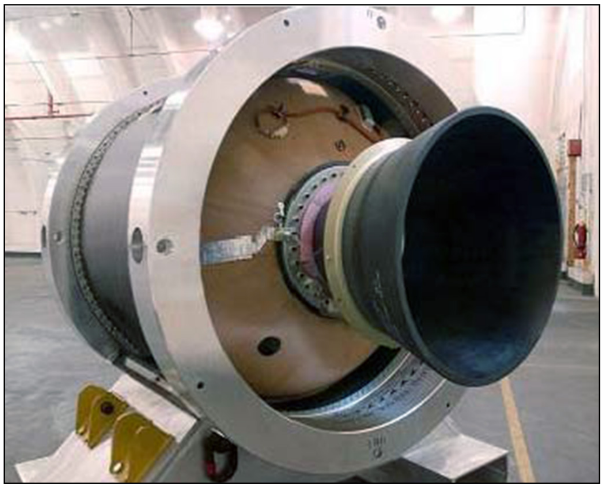

Figure 1. An Orbital ATK Orion 38 solid rocket motor (SRM). The motor is 0.965 m in diameter and 1.346 m in length, with a burn-out mass of 110 kg. Source: ATK Space Propulsion Products Catalog, 14 May 2008, p. 13.

ISS Performs PDAMs

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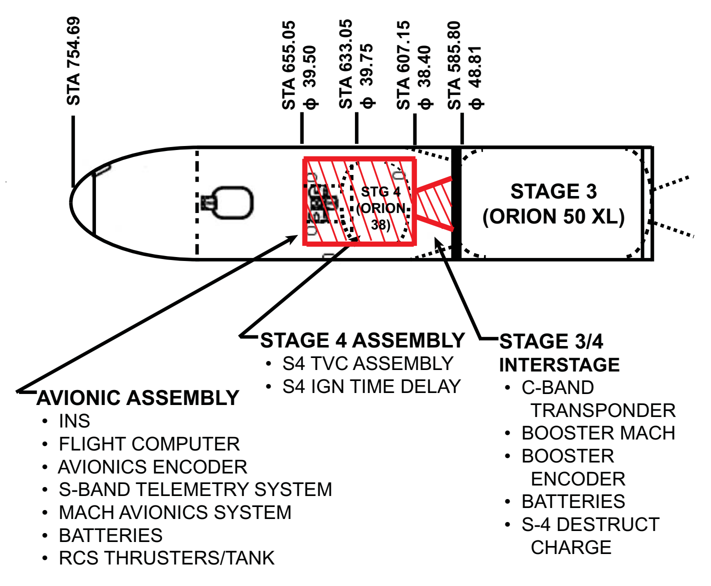

Figure 2. The integrated Minotaur I fourth stage vehicle incorporates not only the Orbital ATK Orion 38 solid rocket motor, but also flight avionics and a nitrogen cold gas reaction control system (RCS). Length is approximately 1.8 m and maximum diameter is approximately 1.0 m. Source: Orbital Minotaur I User's Guide, Release 1.1, January 2006, p. 4.

Shelter-in-Place occurrence in the ISS history. The METEOR 2-5 debris was roughly the same size as the fragment from the 23 April PDAM. It was in a 446 x 408 km, 81.2° orbit at the time of the conjunction. This object created two additional conjunctions (one prior and one after the Shelter-in-Place), but neither were close enough to take any action. ♦

Aerodynamic Breakup of Breeze-M Tank

The Joint Space Operations Center (JSpOC) notified NASA of the confirmed breakup of a Breeze-M (or Briz-M) tank (2014-064C, SSN# 40279) on 17 June 2015. At the time of the notification, the tank was in a 4690 x 100 km orbit and was within 12 hours of reentering the Earth's atmosphere. The tank fragmented into more than 90 pieces, possibly several hundred. All of the pieces reentered within 11 hours of detection of the breakup. Due to the short lifespan of the debris cloud, an accurate piece count and an estimated time of breakup were not determined.

The Breeze-M upper stage was used to launch the Express AM-6 communications satellite in October 2014. The toroidal tank, referred to variously as the Additional Fuel Tank (AFT) or Auxiliary Propulsion Tank (APT) but as the *Dopolnityelneë toplivneë bak*, DTB, in its native Russia, fits around the core Breeze module and provides additional fuel and oxidizer. The tank is typically discarded after its use. Separated, the tank has a length of approximately 2.47 m and inner and outer diameters of 2.49 and 4.10 m, respectively. Dry mass is on the order of 1290 kg. Figure 1 illustrates the finer details of the APT, while Figure 2 compares the Breeze-M stage before and after the APT is jettisoned. ♦

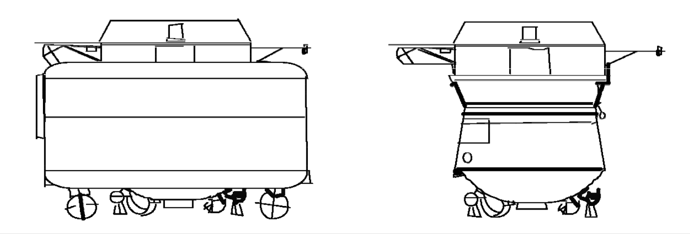

Figure 2. A comparison of the Breeze-M stage, with the APT (left) and after-APT jettison (right). Source: Proton Launch System Mission Planner's Guide, Rev. 7, July 2009, App. A.

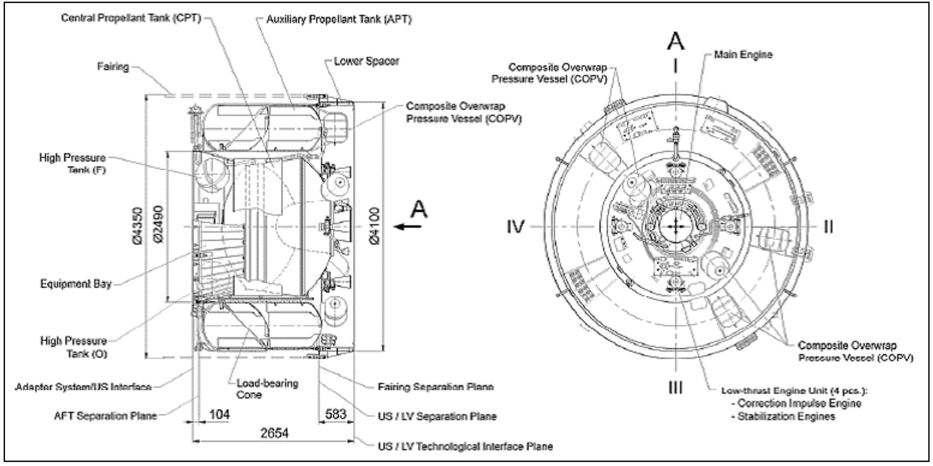

Figure 1. The Breeze-M fourth stage of the Proton-M launch vehicle. The Auxiliary Propulsion Tank (APT) is the toroidal structure around the core stage. Source: Proton Launch System Mission Planner's Guide, Rev. 7, July 2009, App. A.

MCAT Telescope on Ascension Island: Installation Success!

On 18 June 2015, NASA and the U.S. Air Force Research Laboratory (AFRL) hosted an open-house to celebrate completing the Meter Class Autonomous Telescope (MCAT) facility installation, and to thank the many people – U.S. Air Force and Royal Air Force, military, civilians and contractors, and local employees who contributed their time, expertise, attention to detail, and care in making MCAT not just another observatory, but a top-quality facility. MCAT is a unique telescope, one of only two like it in the world – a double-horseshoe mount telescope designed by DFM Engineering that allows NASA to track not just Geosynchronous Orbit (GEO) debris, but fast-moving low Earth orbit (LEO) debris. The quick responding telescope regularly elicits comments like: "Does it make anyone else nervous how fast this telescope moves?". The equally fast-tracking dome encloses the telescope, built by ObservaDOME Laboratories, Inc., the same company who built the Ground-based Electro-Optical Deep-space Surveillance System (GEODSS) domes that protect telescopes in harsh environments like that at Diego Garcia, British Indian Ocean Territory (Figure 1).

This combination is key in following debris targets in any direction across the sky by eliminating both the blind-spot at the zenith that is so typical of astronomical telescopes as well as the need to flip the telescope when it crosses the meridian. It is a unique and perfect combination to enable NASA to deepen our understanding of the debris environment around Earth.

In prior months, the NASA Orbital Debris Program Office (ODPO) representatives visited the island's Two Boats School twice, introducing the MCAT project to the children and asking for their help in designing an MCAT logo. The winning MCAT logo features a small turtle as a reminder of the shared love of dark skies between astronomers and turtles alike (Figure 2).

After 9 months of anticipation as the facility was built, with only a one day's advance notice of the open house published in the local newspaper, news had spread, and from the beginning of the event, cars arrived in a steady stream. Over 300 people showed up (including at least half the school children bussed in during a school-wide sleep-over), some of whom are shown in Figure 3. Everyone had an opportunity to see the 20,000 lb., fast-tracking telescope move, ask questions, marvel in the many astronomical images on the TV screen outside, and enjoy a live band.

A dedication ceremony led by the team on-island and web-cast to include project members at NASA JSC dedicated the facility (Figure 4 shows members of the ODPO Optical Measurements Group, who will operate MCAT).

In an event hoped to be worthy of the observatory's namesake, John Africano, a legend in the field of debris and loved by many in the debris community, the facility was named "The John Africano NASA/AFRL Orbital Debris Observatory." ♦

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Figure 1. MCAT fast-tracking telescope built by DFM Engineering, enclosed by the equally fast-tracking Observa-DOME Laboratories Inc. dome. Photo courtesy of LAC Hanna, Royal Air Force.

Figure 2. The MCAT logo complete with turtle, a damaged satellite (debris), and the Southern Cross representing our southern-hemisphere location on Ascension Island. Ascension Island is a prime destination for turtles, whose hatchlings are guided by moonlight to the ocean. Residents alter the lighting to keep the skies as dark as possible, providing a benefit both to the turtles and to the astronomers.

Figure 3. In total, the MCAT dedication ceremony was attended by over 300 children and adults from Ascension Island (the rest of the crowd is all lined up to see the telescope). Photo courtesy of Leading Aircraftman (LAC) Hanna, Royal Air Force.

MCAT Installation

continued from page 3

Figure 4. The ODPO Optical Measurements Group contributed to building and testing the telescope and will operate MCAT. The data will be preprocessed onsite and sent to the ODPO for thorough data reduction and analysis, after which it will be used to update environmental models. Pictured here: Dr. James Frith (Jacobs/University of Texas, El Paso [UTEP]), Dr. Heather Cowardin (Jacobs/UTEP), and Dr. Sue Lederer (NASA; Principal Investigator for MCAT). Not pictured: Dr. Brent Buckalew (Jacobs). Special mention and thanks to Tom Glesne (AFRL/Schafer Corp.); Riki Maeda, Daron Nishimoto, and Dennis Douglas (Integrity Appl. Inc.); Dr. Paul Hickson (Euclid Research Corp.); and Lisa Pace (NASA JSC, Project Manager for MCAT), whose contributions were critical to the success of this project, and to those who dreamed up the idea, including ODPO Program Manager Gene Stansbery (NASA). Photo courtesy of LAC Hanna, Royal Air Force.

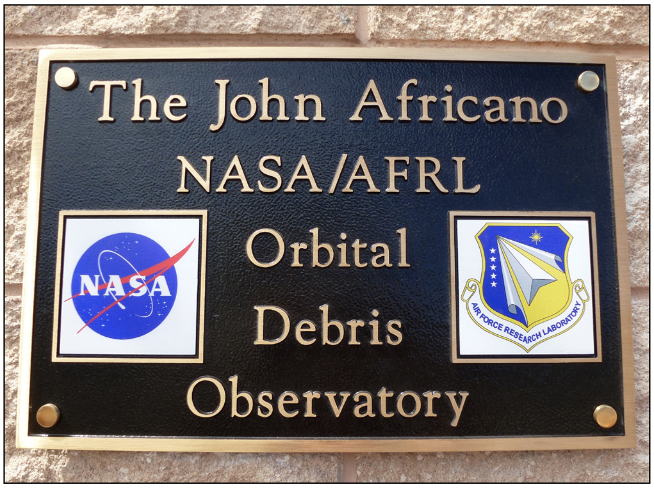

Figure 5. The plaque dedicating MCAT and immortalizing John Africano, a dedicated ODPO teammate. He made many significant contributions to the optical observation and measurement of orbital debris during his carrer, and brought NASA and AFRL together to begin discussions on building a meter-class telescope co-located with radar assets. John may be remembered by some as the co-organizer of the Advanced Maui Optical and Space Surveillance (AMOS) Technical Conference, which is held each September (see ODQN 10-4, October 2006, p.2 for a tribute that summarizes his career).

PROJECT REVIEW

A Review of Space Environment Implications of CubeSat Traffic, 2003-2014

P. ANZ-MEADOR

CubeSats and large constellations are of considerable recent interest, with an upsurge in CubeSat space traffic in 2013-2014, and plans for the aggressive deployment of CubeSat and larger spacecraft constellations in the near future. Such deployments may influence the orbital debris environment in low Earth orbit (LEO) and are of interest in the degree that operators adhere to established debris guidelines.

Since the introduction of the CubeSat standard, 231 CubeSats or similar format spacecraft have been launched, with another 44 being lost in launch failures, up to 1 January 2015 (hereafter, the "date"). The standard defines a 1-unit (1U)-spacecraft as having a cubical dimension of 10 cm and a mass of approximately one kg. Variations on this range from 0.5U to 27U, though to date only two 6U-spacecraft have been launched. Similar form factors include the Canadian Generic Nanosatellite Bus (GNB), equivalent to an 8U CubeSat, and the PocketQube form factor, with a 1-unit (1Q)-spacecraft being 5 cm on a side. In addition to commercial, scientific, and technology demonstration missions, CubeSats have demonstrated the ability to deploy other, smaller spacecraft.

Figure 1 depicts the cumulative launch record to date. Categories are 1-3U, "other" U (*e.g.*, 0.5U, 2.5U, 6U), GNB, and PocketQubes. Of primary interest is the approximately equal popularity of 1U- and 3U-spacecraft, dominating the much lesser, though again approximately equal, popularity of 2U and "other" U form factors. Also evident is the surge in traffic since 2013, and the recent, and limited, use of the smaller PocketQube form factor. An examination of the apparent surge, however, reveals that multiple cluster launches in 2013 were responsible for 77 CubeSats launched that year, while in 2014 that number reduces to 35, with 33 being launched from the International Space Station (ISS) and another 5 from ISS visiting vehicles. This pattern of deployments has bearing on the lifetimes of the spacecraft and therefore their long-term impact, if any, on the LEO environment. Figure 2 depicts the historical

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CubeSat Traffic

continued from page 4

traffic and orbital locations as of March 2015. Clustering in certain orbit parameters is due to the predominant launch mode and cluster launches aboard SL-24/*Dniepr*, Atlas Centaur, Minotaur, and other space launch vehicles.

As shown in Figure 3, CubeSat–type spacecraft owner/operators are primarily from the U.S., Germany, and Japan, though other countries contributed almost 30% to the historical traffic due to the relative ease of construction and minimal cost. The 2013 $50Sat, a 1.5Q format CubeSat, is an extreme case in point.

A standard ODPO software tool was used to estimate an area-to-mass (A/m) ratio, assuming a drag coefficient of 2.2 in LEO, from observed orbital decay. The A/m distribution for spacecraft with available orbital elements is shown in Figure 4.

This distribution's individual values are typically larger than the so-called "engineering" A/m, the latter equal to the randomly-tumbling

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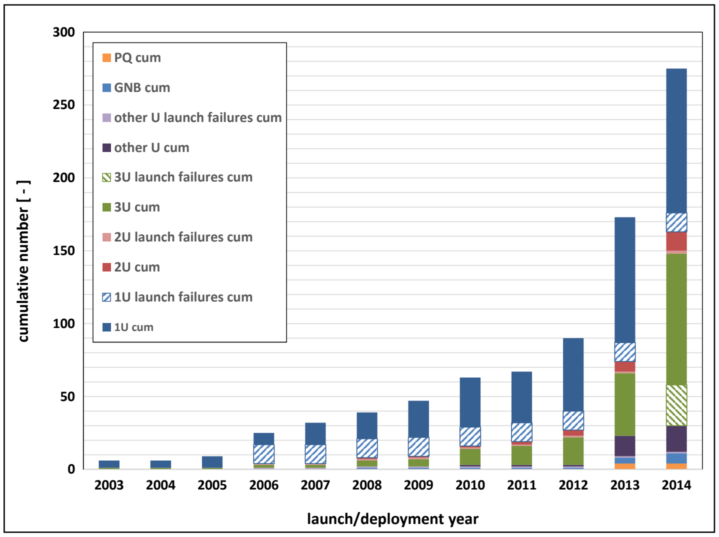

Figure 1. Cumulative launch record, including launch failures to portray the intended record. A steady rise is shown from 2006 – 2012 with a leap from ~90 to 173 in 2013 and then to 275 in 2014. Source (this and all subsequent figures): NASA Orbital Debris Program Office (ODPO) space traffic database and Department of Defense Joint Space Operations Center (JSpOC) catalog products.

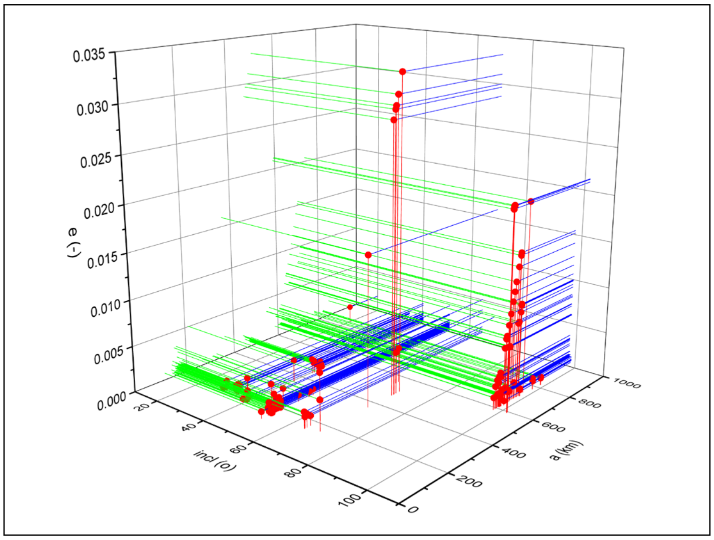

Figure 2. March 2015 orbital parameter distributions of the CubeSat ensembles show clusters between 600 and 1000 km with inclinations between 45 and 98 degrees.

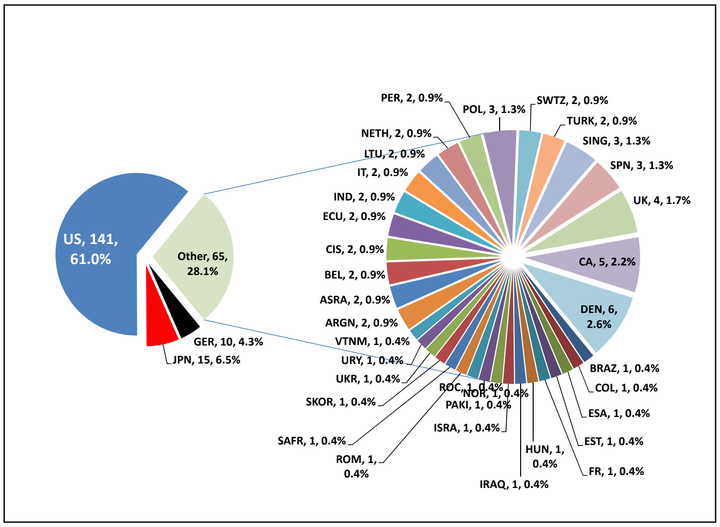

Figure 3. Attributed launch source countries. The United States has 141 launches at 61%; followed by Japan with 15 launches, 6.5%; Germany with 10 launches, 4.3%; and the remaining 65 launches, 28.1% represented by "other." Source: JSpOC Satellite Catalog.

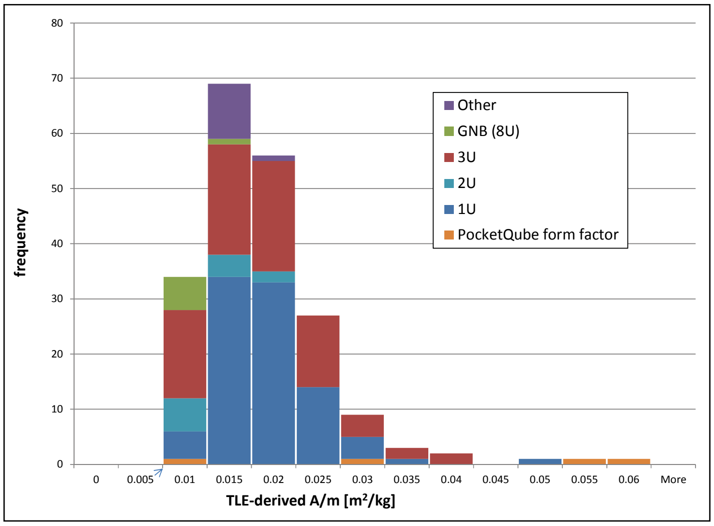

Figure 4. Estimated A/m distribution. Horizontal axis values refer to the right side of the A/m bin, as indicated by the small arrow at the 0.005 m²/kg. In general, A/m values tend to be a minima at their "engineering" value, and display increased A/m in their distribution due to appendages.

CubeSat Traffic

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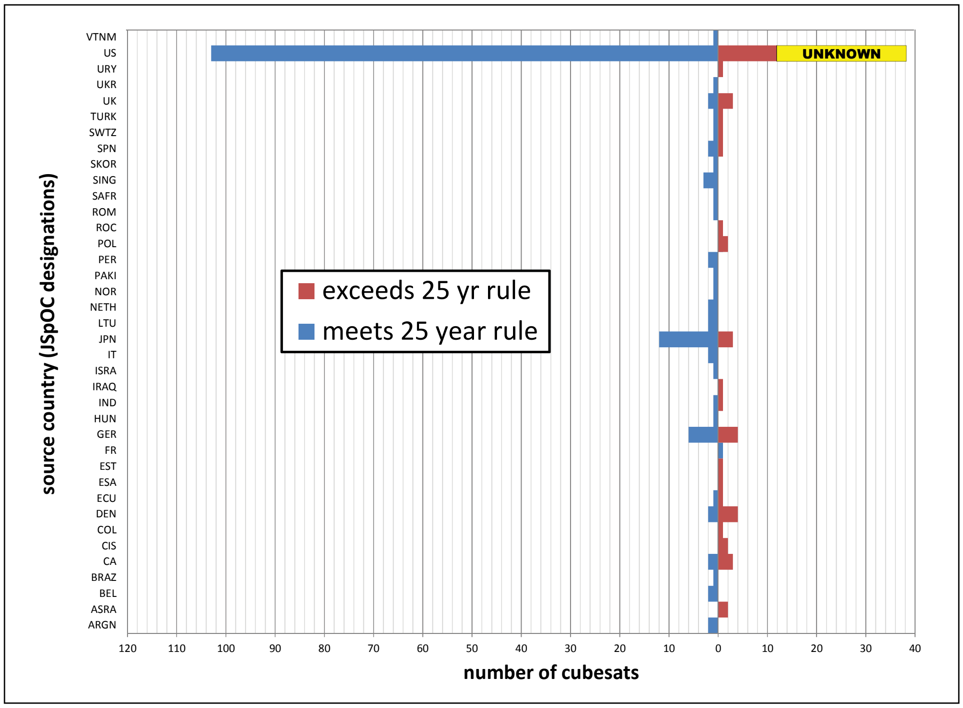

Figure 5. Projected compliance with the internationally-accepted 25-year guideline. This figure is based on 25 years on-orbit, following an assumed 2-year operational life, as the zero point. Note that orbital elements are not available for some U.S. CubeSats, hence these are "Unknown."

area (one-fourth of the total surface area for convex objects without self-shadowing) divided by the (dry) mass.

When propagated forward, it is evident that CubeSats with semimajor axes between 600 and 700 km are on the boundary between compliance with the internationally accepted guideline of 25 years on orbit, following mission completion, for spacecraft in LEO. This projection assumes an operational lifetime of 2 years. At higher altitudes, all CubeSats display longer on-orbit lifetimes and non-compliant residence times. Lower altitude deployments, such as those from the ISS, are projected to be compliant.

Compliance with the 25 year guideline, differentiated by the JSpOC satellite catalog country or source identifier, is depicted in Figure 5. In general, the majority of CubeSats are compliant with this guideline.

An examination of the available orbital data for all CubeSats, including the smaller PocketQubes, indicates that all are tracked. However, two unique case studies present themselves. The Nanyang Technical University (Singapore) VELOX-1N (nano) was intended to deploy the VELOX-PIII (pico) subsatellite. The subsatellite was not released, as the Principal Investigator related that it would be so released only if the university team was very certain that it would not cause conjunction issues with other resident space objects. The Pontifica Universidad Catolica del Peru PUCP-Sat 1, a university 1U CubeSat, deployed the 97 g-Pocket-PUCP on 6 December 2013. This subsatellite has not entered the JSpOC catalog and is assumed to be untracked.

In summary, while 1U and 3U CubeSats are the most common form factors, there appears to be a trend towards 3U CubeSats in 2013 and later space traffic. An increase in 2014 traffic is mitigated somewhat by the relatively short lifetimes of those CubeSats deployed from the ISS or visiting vehicles. An assessment of observed A/m values and subsequent propagation into the future indicates that most CubeSat form factor spacecraft, flown by all countries, meet the 25-year rule, and with the exception of one deployed subsatellite, all are trackable. ♦

MMOD Risk Assessments for EVA

E. CHRISTIANSEN, J. HYDE,
K. HOFFMAN, AND D. LEAR

During 2015, NASA is celebrating 50 years of spacewalking or Extravehicular Activity (EVA), recognizing how EVA enhances and enables human exploration of the solar system. Although EVAs typically occur over 6.5 hours or less and the EVA suits expose a relatively small area to micrometeoroid and orbital debris (MMOD) impact, there is still a small but non-zero risk of a suit puncture from MMOD. The NASA Johnson Space Center (JSC) Hypervelocity Impact Technology (HVIT) group provides MMOD risk assessments for each EVA performed by NASA using Bumper code, the latest MMOD environment models (ORDEM 3.0 debris model and MEM-R2 meteoroid model), and results of hypervelocity impact tests. Two assessments are performed for each EVA: (1) any-size leak risk assessment which would likely result in early termination of the

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MMOD Risk Assessments

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EVA, and (2) a large or uncontrolled leak due to a 4 mm or larger hole in the bladder of the suit, which exceeds the secondary oxygen supply of the suit and would potentially be catastrophic for the astronaut in the suit. The finite element model of the EVA suit that is used in the Bumper code MMOD risk assessments is shown in Figure 1, and is divided into 41 regions based on differences in the materials of construction, MMOD penetration resistance, and failure criteria. A typical MMOD risk assessment for an EVA will consider many different suit orientations and work locations to match the projected EVA timeline (Figure 2).

Over 100 hypervelocity impact tests have been performed on various areas of the suit to develop equations predicting leak and hole sizes in the bladder of the arms, legs, briefs and gloves (*i.e.*, soft goods), as well as failure of the hard goods such as helmet, hard upper torso, bearings and the back pack which is the portable life support system (PLSS). Figure 3 shows an example of an impact test on the basic suit layup representative of a majority of the arms, legs and briefs, which indicates that a 0.5 mm-diameter aluminum projectile at 6.84 km/s will cause slight darkening of the bladder but does not result in a hole or leak of the bladder. In some cases the bladder materials were pressurized by either inert gas or pure oxygen to operating suit pressure (4.3 psi), to determine how a stressed or loaded bladder reacts to hypervelocity impact, as well as to determine the consequences of penetrations into the nearly pure oxygen interior. Results of the tests were used to develop ballistic limit equations (see Figure 4 as an example), which were incorporated into the Bumper code and MMOD risk assessments. Details of the impact tests have been published [1]. The EVA MMOD risk assessments also include the effects of recent debris generating breakups (supported by the

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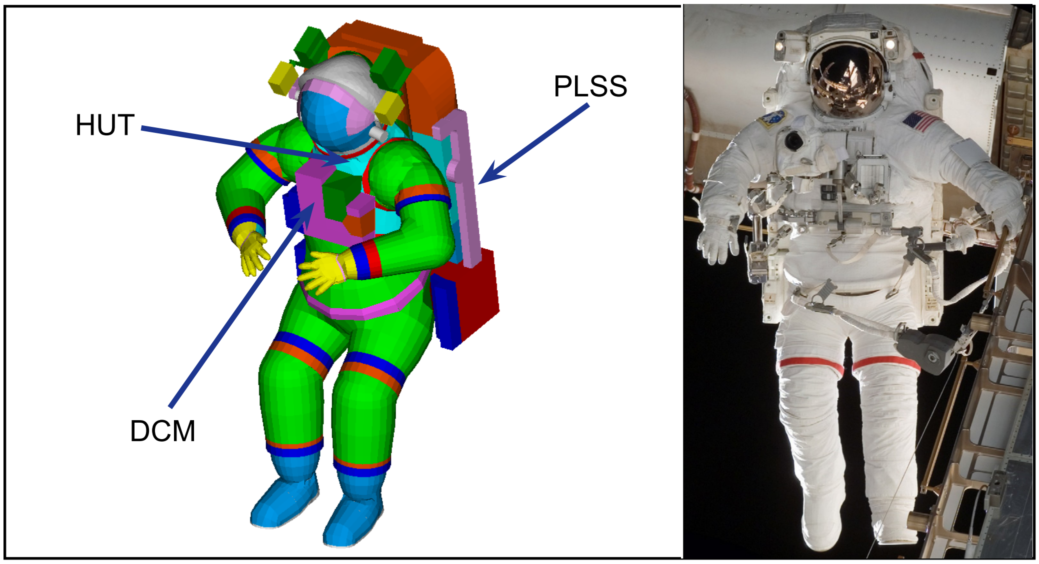

Figure 1. Finite element model of the EVA suit used in the MMOD risk assessment. DCM = digital control module, HUT = hard upper torso, PLSS = portable life support system. The figure shows both the finite element model [FEM] (left image) and actual suit (right image).

EMU Worksite Locations

EVA 29	EVA 30	EVA 31
1 - 9	1, 2, 8, 10-19	1, 20-24

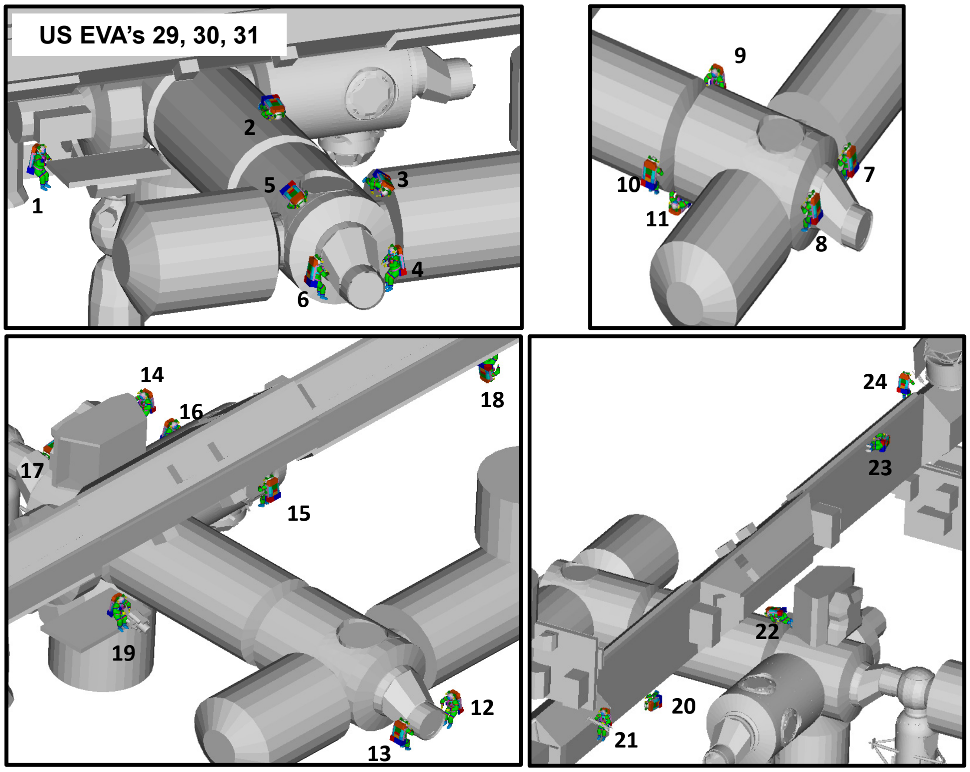

Figure 2. Several different EVA suit locations and orientations are considered for each EVA risk assessment.

MMOD Risk Assessments

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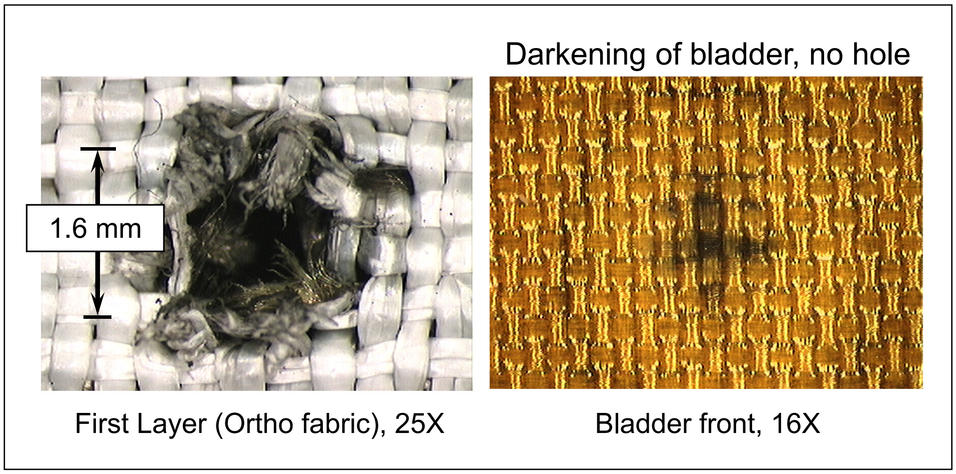
Orbital Debris Program Office at JSC) and meteor showers and storms (supported by the Meteoroid Environment Office at Marshall Space Flight Center). Nominal combined MMOD risks for both crew on a 6.5-hour EVA are on the order of 1 in 7,000 for any size leak and 1 in 35,000 for catastrophic holes.

Reference

Christiansen, E.L., Cour-Palais, B.G., Friesen, L.J. "Extravehicular Activity Suit Penetration Resistance," International Journal of Impact Engineering, Vol. 23, pp. 113-124, (1999). ♦



First Layer (Ortho fabric), 25X

Bladder front, 16X

Figure 3. Microscope images from HITF Test A2930 on a basic suit layup (representative of the majority of the arms, legs, and briefs) with a 0.5 mm-diameter aluminum spherical projectile, impacting at 6.84 km/s and at a 30 degree impact angle to the suit normal. A 1.6 mm-diameter hole was created in the outside "ortho-fabric" layer of the suit, while the bladder was darkened but intact.

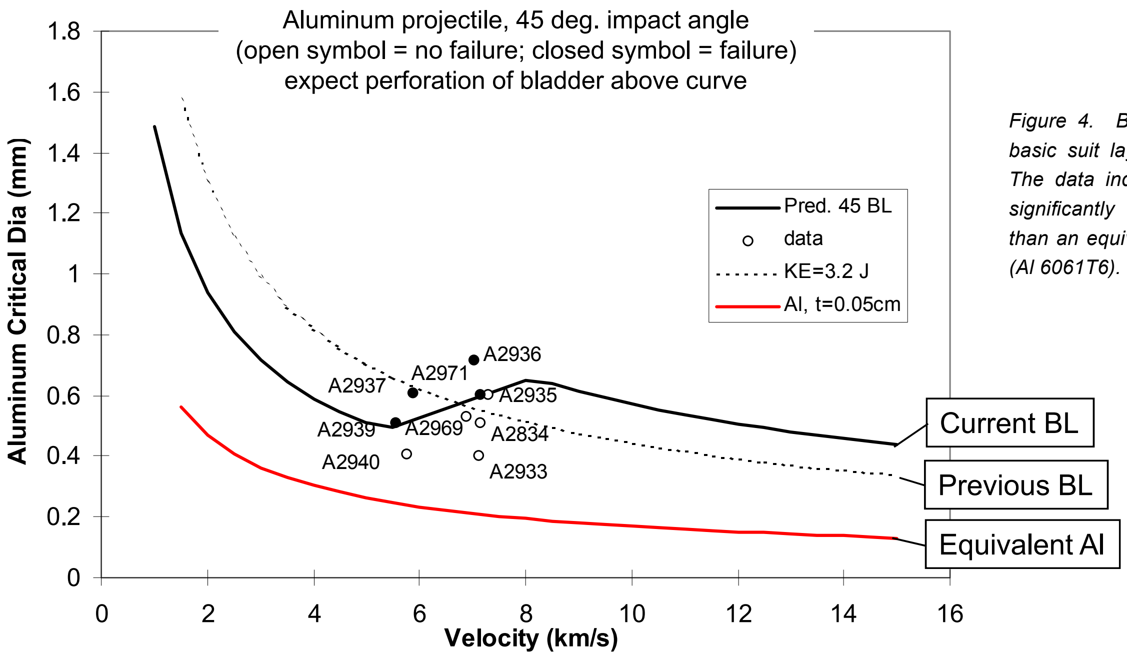


Figure 4. Ballistic limit data for the basic suit layup (from Reference 1). The data indicates the suit provides significantly more MMOD protection than an equivalent mass of aluminum (Al 6061T6).

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CONFERENCE REPORT

The 30th International Symposium on Space Technology and Science (ISTS), 04-10 July 2015, International Conference Center, Kobe-Hyogo, Japan

The 30th International Symposium on Space Technology and Science (ISTS) took place on 4-10 July at the International Conference Center in Kobe-Hyogo, Japan. Eight sessions were dedicated to orbital debris. The optical observation session included presentations on LEO object detections and light curve observations. The in-situ measurement session included papers on the NASA ISS DRAGONS project and JAXA's impact sensor for the upcoming HTV-5 mission. The modeling session included papers on the dynamics of small debris and assessments of the impact to the LEO environment from mega-constellations of small satellites. The two protection sessions included several papers on hypervelocity impact tests and papers on shielding design and reentry predictions. The remaining three sessions focused on active debris removal (ADR). JAXA provided two presentations on an electrodynamic tether test to be conducted during the HTV-5 mission. Several papers addressed the target capture mechanisms for ADR based on net, harpoon, and robotic arm. A Singapore-based private company also described their design of an ADR system and their plan to carry out a demonstration mission in the coming years.

This year's ISTS was held in conjunction with the 34th International Electric Propulsion Conference and the 6th Nano-Satellite Symposium. This joint event provided a unique opportunity for many cross disciplinary discussions among participants from different communities. ♦

UPCOMING MEETINGS

08-13 August 2015: The 29th Annual AIAA/USU Conference on Small Satellites, Logan, Utah

The 29th Annual AIAA/USU Conference on Small Satellites will discuss commercial, educational, and government developed and planned satellites ranging from pico-sats to 100 kg satellites. In addition to the 12 technical sessions there will be a number of side meetings, including two on orbital debris. Additional information is available at http://www.smallsat.org.

31 August - 02 September 2015: AIAA SPACE 2015, Pasadena, California

Among the relevant sessions at this year's conference are Atmospheric and Space Environments, including meteoroid and debris environments, on-orbit spacecraft and environmental interactions, and space environment measurement, modeling, and prediction; Reinventing Space; Small Satellites; and Space Systems, including proximity sensing of space objects and orbital Space Situational Awareness (SSA), and cubesats. For more information, please see the conference website at: http://www.aiaa-space.org/.

15-18 September 2015: The 16th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS)

The technical program of the 16th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS) will focus on subjects that are mission critical to Space Situational Awareness. The technical sessions include papers and posters on Space Situational Awareness, Adaptive Optics & Imaging, Astrodynamics, and Non-resolved Object Characterization. One of the technical sessions is dedicated to Orbital Debris. Additional information about the conference is available at http://www.amostech.com.

12-16 October 2015: The 66th International Astronautical Congress (IAC), Jerusalem, Israel

The Israel Space Agency will host the 66th IAC Conference with a theme of "Space – The Gateway for Mankind's Future." Like the previous IAC Conferences, the 2015 Congress will include a Space Debris Symposium to address the complete spectrum of technical issues of space debris measurements, modeling, risk assessments, reentry, hypervelocity impacts and protection, mitigation and standards, and space situational awareness. These topics will be covered in nine oral sessions and one poster session. For conference information as it is posted, visit the IAF conference webpage at http://iac2015.org.

SATELLITE BOX SCORE

(as of 1 July 2015, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	178	3528	3706
CIS	1461	4821	6282
ESA	52	45	97
FRANCE	59	449	508
INDIA	59	106	165
JAPAN	136	73	209
USA	1306	3876	5182
OTHER	666	110	776
TOTAL	3917	13008	16925

Visit the NASA Orbital Debris Program Office Website

www.orbitaldebris.jsc.nasa.gov

Technical Editor
Phillip Anz-Meador

Managing Editor
Debi Shoots

Correspondence concerning the ODQN can be sent to:

Debi Shoots
NASA Johnson Space Center
Orbital Debris Program Office
Mail Code JE104
Houston, TX 77058

debra.d.shoots@nasa.gov

National Aeronautics and Space Administration
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INTERNATIONAL SPACE MISSIONS

1 April 2015 – 30 June 2015

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2015-021A	DRAGON CRS-6	USA	399	404	51.6	1	2
2015-022A	THOR 7	NORWAY	35775	35799	0.0	1	1
2015-022B	SICRAL 2	FRANCE/ITALY	35781	35790	0.0		
2015-023A	TURKMENALEM 52E/ MONACOSAT	TURKMENISTAN/ MONACO	35778	35794	0.0	1	0
2015-024A	PROGRESS-M 27M	RUSSIA	140	151	51.6	1	20
2015-025A	OTV 4 (USA 261)	USA	NO ELEMENTS AVAILABLE			1	0
2015-025B	USS LANGLEY	USA					
2015-025C	OPTICUBE 01	USA					
2015-025D	PARKINSONSAT (PSAT)	USA					
2015-025E	BRICSAT-P	USA					
2015-025F	OPTICUBE 02	USA					
2015-025G	GEARRS-2	USA					
2015-025H	OPTICUBE 03	USA					
2015-025J	AEROCUBE 8A	USA					
2015-025K	AEROCUBE 8B	USA					
2015-025L	LIGHTSAIL-A	USA					
2015-026A	DIRECTV 15	USA	35784	35790	0.1	1	1
2015-026B	SKY MEXICO-1	MEXICO	35778	35795	0.0		
2015-027A	COSMOS 2505	RUSSIA	195	261	81.4	1	0
2015-028A	SENTINEL 2A	ESA	788	790	98.6	1	0
2015-029A	COSMOS 2506	RUSSIA	707	726	98.3	1	0
2015-030A	GAOFEN 8	CHINA	485	492	97.3	1	0

Errata for ODQN "International Space Missions"

The ODQN 19-2 listed four payloads as "EN ROUTE TO GEO". International designators 2015-010A and B, the People's Republic of China's ABS 3A and the European Telecommunications Satellite Organization's EUTELSAT 115W B/SatMex 7, respectively, are still en route, *via* supersynchronous transfer orbit, as of 6 July 2015. Designator 2015-012A, the Russian Express AM-7 spacecraft, has arrived at an orbit of 35800 x 35772 km, 0.01° inclination. The Indian Regional Navigation Satellite System (IRNSS) 1D spacecraft, 2015-018A, has also reached its intended orbit of 35878 x 35694 km, 30.33° inclination.

International designators 2015-020A-E were described as Objects A-E, retaining their JSpOC placeholder names. Piece tags A-C have since been identified as Gonets M11 (M21), M12 (M22), and M13 (M23) respectively. Object D is identified as Cosmos 2504, and Object E is the Breeze-KM rocket body. It's highly likely that this launch is a repeat of the 2013-076 and 2014-028 launches; in both cases, the maneuvering Cosmos spacecraft was later identified as carrying an amateur radio payload in the Radio Sputnik series. Since its launch, Cosmos 2504 has demonstrated a maneuver capability on multiple occasions.