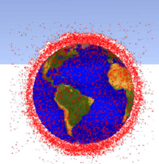
National Aeronautics and Space Administration

Orbital Debris Quarterly News

Volume 20, Issue 3
July 2016

Inside...



A publication of the NASA Orbital Debris Program Office

Two Additional Russian Breakups in 2016

A SOZ (*Sistema Obespecheniya Zapuska*) ullage motor, or SL-12 auxiliary motor, from a Proton Block DM fourth stage has been identified as a possible breakup. These motors have a long history of fragmentations. This event is the 45th breakup of this class of object over its history and is the sister of the SOZ unit whose 27 March 2016 breakup was reported in the previous Orbital Debris Quarterly News (ODQN, vol. 20, combined issue 1/2, April 2016, p. 4). Ullage motors, used to provide three-axis control to the Block DM during coast and to settle propellants prior to an engine restart, are routinely ejected after the Block DM stage ignites for the final time. This SOZ unit (International Designator 2008-067H, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog number 33473) is associated with the launch of the Cosmos 2447-2449, members of the Russian global positioning navigation system (GLONASS) constellation.

The motor was in a highly elliptical 18786 x 709 km orbit at an inclination of 65.27° at the time the NASA Orbital Debris Program Office was notified of the possible breakup on 1 June 2016. Due to difficulties in tracking objects in deep space elliptical orbits, this event may have produced many fragmentation debris.

The second event was the aerodynamic breakup of the Molniya 1-93 spacecraft (International Designator 2004-005A, SSN #28163) on 15 April 2016. The estimated breakup time was 1300 GMT ± one hour. At the time of the event the spacecraft was in a 2145 x 77 km altitude orbit at an inclination of 62.96°; Molniya 1-93 decayed from orbit on 16 April 2016. Thirteen pieces were tracked by the SSN, but none entered the SSN catalog. Due to the parent spacecraft's very low perigee altitude, the orbital lifetime of all pieces was short and the risk presented to other resident space objects minimal. ♦

Former NASA Chief Scientist for Orbital Debris Receives Loftus Award

Mr. Nicholas L. Johnson, retired NASA Chief Scientist for Orbital Debris, was awarded the prestigious Joseph P. Loftus Space Sustainability Award by the International Association for the Advancement of Space Safety (IAASS). The award was presented during their 8th IAASS Conference (http://iaassconference2016.space-safety.org/) banquet, held at the Kennedy Space Center Visitor Complex in Titusville, Florida on 19 May. The large, silver-plated bronze plaque and calligraphic fine-art certificate were both custom made for the event by noted Italian artist Nicola Settanni. ODPO's Dr. Mark Matney accepted the award from IAASS president Isabella Roninger on behalf of Mr. Johnson, who could not be there in person. In accepting the award, Mark added his own comments of praise for his deserving colleague.

Background details about the award and its namesake are provided on the IAASS website (http://iaass.space-safety.org/awards/11th-hour-sustainability/). "The Joseph Loftus Space Sustainability Award is awarded to an individual, or to a team, which has made outstanding contributions in the field of space sustainability." The Award "is named after Joseph (Joe) P. Loftus (1930-2005), who was the early proponent of orbital debris research, gained an international reputation in that field and is known as the godfather of the NASA Orbital Debris Program Office.

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Loftus Award

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Space Sustainability Award Criteria

The criteria for the Joseph P. Loftus Space Sustainability Award is rooted in recognizing individuals, organizations and/or Institutions who have championed preservation and sustainability of the space environment for the greater good of the future generation and the whole mankind. The recipient of this award must have demonstrated contributions in elevating sustainability of space Ecology in par with the traditional mission success/assurance of any space journey imperatives. The recipient of this award must be a fully recognized advocate and promoter of sustainable space environment though mitigation and reduction of manmade debris. The recipient of this award has been actively engaged in institutionalizing a tight connection between space safety and sustainability. The nominee shall meet at least three of following five criteria:

1. Demonstrated contribution and leadership in promoting sustainable space for the past 15 years.

2. Active participant in promoting the development of space systems which will have near zero footprints.

3. Contributed significantly to the expansion of knowledge and preservation of space environment.

4. Developer of advanced space systems and operational mitigations aimed to improve and maintain space sustainability

5. Author of books, technical papers, and noted lecturer/speaker who promotes, champions and instills space sustainability in the consciousness of the private and government sectors

6. Relentlessly fosters creation of a set of scientifically based procedures and standards by all spacefaring entities to ensure harmonious implementation of safety and sustainability principles for the space

7. Inspiring leader and mentor advocating for novel ideas in space sciences, education and reenergizing and revamping space professional.

Figure 1. NASA ODPO's Dr. Mark Matney (center) receives the Loftus award from Dirk Hoke, Chief Executive Officer of Airbus Defence and Space, the sponsor for the award. IAASS president Isabella Roninger is on the left.

Joe Loftus was among the first to alert NASA officials to the danger to spacecraft and satellites posed by increasing amounts of spent rocket bodies, fragments from spacecraft and other debris from space operations. His efforts led, in 1979, to the first official funding for orbital debris research at NASA. The space agency established the Orbital Debris Program Office, which also deals with potential contamination of the orbital environment."

Thus, in recognizing one of the recently retired greats of ODPO – Nicholas Johnson – with an award named for Joe Loftus, its founder, and accepted by an active member of ODPO, the event simultaneously highlighted the ongoing important work of the ODPO from its conception, through its key evolutions, to its current scientists. ♦

Figure 2. The Loftus award "consists of a bronze plaque reproducing in bas-relief a pocket watch with hands on the 11th hour. It symbolizes the fast approaching deadline to prevent the Kessler Syndrome, a scenario in which the density of space debris in low Earth orbit is high enough that collisions between objects could cause a cascade… which increases the likelihood of further collisions…" (http://iaass.space-safety.org/awards/11th-hour-sustainability).

Titan Transtage Arrives at JSC to be Studied by Orbital Debris Scientists

A Titan Transtage test article arrived at NASA's Johnson Space Center on 26 May 2016. The article will be studied by scientists in the Orbital Debris Program Office (ODPO) to obtain information to complete forensics that will aid the interpretation of telescopic survey measurements and data to incorporate into computer models of the near-Earth space environment.

The Martin Marietta Transtage, an upper stage of the Martin Marietta Titan III rocket family, was developed in the 1960s to lift heavy payloads or multiple small payloads to specific locations in low-Earth orbit (LEO) and Geosynchronous Earth Orbit (GEO). The Transtage was the world's first "space tug" capable of multiple restarts of its engine, and could deliver multiple spacecraft to precise orbits in a single mission. NASA used the Transtage to launch the agency's Applications Technology Satellite (ATS) 6, which pioneered GEO three-axis stabilization, deployable and steerable large antennas, electric thrusters, direct broadcast TV, and educational TV programming in concert with the Indian Space Research Organization. Proposals to couple one or more Transtage vehicles with the Gemini spacecraft for space rescue or early lunar reconnaissance were not developed.

After an earlier career with the Air Force Orientation Group and the Air Force Museum, the Transtage was found resident at the U.S. Air Force's 309th Aerospace Maintenance and Regeneration Group, better known as the "Boneyard," at Davis-Monthan Air Force Base in Tucson, Arizona. A June 2015 inspection by ODPO scientists Anz-Meador and Cowardin determined that while the Transtage object was likely an engine test article, rather than an unflown vehicle, it contained sufficient original components and details that it would be valuable to bring to JSC to characterize completely. Figures 1 - 4 show the Transtage's journey from the "Boneyard" to its current berth.

Transtage vehicles are known to have fragmented in GEO. Orbital debris scientists regularly conduct telescopic observations of the GEO region to characterize the debris

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Figures 1 - 4 (clockwise from upper left). 1) The Titan Transtage is lifted onto a tractor-trailer for transport to NASA JSC. It was found at the U.S. Air Force's Aerospace Maintenance and Regeneration Group, "the Boneyard," at Davis-Monthan Air Force Base in Tucson, Arizona. In the background are KC-135 Stratotankers in storage. (Image courtesy of Rob Raine, U.S. Air Force 309th Aerospace Maintenance and Regeneration Group). 2) The Titan Transtage arrives at JSC after a road journey shared with curious drivers. Anecdotally, the 18-wheeler was detained going through Houston by a curious sheriff who said "You aren't doing anything wrong. I just wanted to see what this thing was." (Image credit: NASA/David DeHoyos). 3) The Titan Transtage arrives outside the building that will house it during inspection. (Image credit: Jacobs/D Shoots). 4) NASA JSC team members maneuver the Titan Transtage into a holding cradle where scientists with the ODPO optical team will study its properties. (Image credit: NASA/David DeHoyos).

Titan Transtage

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environment down to a limiting magnitude or size. Spectral observations are conducted to identify specific materials on-orbit. ODPO scientists will characterize the spectral features of the materials used in the construction of this 1960s-era rocket body using a spectrometer to collect spectral data, in 1-nm-wide steps, from 350-2500 nm wavelengths, or from the UV to the Infrared. These data will then be entered into a spectral database used to identify space materials by a spectral matching algorithm. ♦

OD Advocate Dr. Dietrich Rex Passes Away

The space debris community has lost one of its pioneers. Prof. Dr.-Ing Dietrich Rex passed away on 18 April, aged 82, after a long illness.

Prof. Rex was a physicist by education and started his career with research work on nuclear powered space missions, electric propulsion and orbit dynamics (very soon with a view on atmospheric re-entries). He obtained his Ph.D. and state doctorate at the Technical University of Braunschweig. In 1970, he was appointed Professor and head of the Spaceflight Technology Department at the Spaceflight and Reactor Technology Institute.

In 1979, after the re-entry of Cosmos-954 over Canada, Prof. Rex joined the Scientific and Technical Subcommittee (STSC) of the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS). His expert knowledge on reactor technology and re-entry dynamics was key to the successful development of the "Principles Relevant to the Use of Nuclear Power Sources in Outer Space," which were adopted by the General Assembly in its resolution 47/68 of 14 December 1992.

Since the mid-1980s, Prof. Rex focused his research on the space debris problem. He established a very fruitful cooperative agreement between the Technical University of Braunschweig and the NASA Johnson Space Center in Houston and in 1987, he became head of the Space Debris Advisory Group of the European Space Agency (ESA). At this time, he also contributed to bilateral meetings between NASA and ESA prior to the formation of the Inter-Agency Space Debris Coordination Committee (IADC), attending the first meeting in 1993 and remaining a constant member of the ESA delegation since then. In 1992, he became head of the Spaceflight and Reactor Technology Institute (today: Institute of Space Systems). Under his leadership, environment evolution models were developed and the fundaments for the ESA MASTER model were laid. His research also was fundamental in developing practicable mitigation measures.

From 1996 - 2000 he was chairman of the STSC of UN COPUOS. Under his leadership, the "Technical Report on Space Debris" was developed and adopted in 1999. In recognition of his valuable contributions, the committee dubbed the document the "Rex Report" (following a proposal of the Greek delegation). Prof. Rex retired in 1999, but remained active and available for his Ph.D. students for several additional years. For his achievements, he was bestowed with the Federal Cross of Merit (twice, in two classes). He will be remembered as a passionate expert and advocate of the space debris community. ♦

(Article courtesy of Dr. Holger Krag, ESA Space Debris Office)

PROJECT REVIEW

MMOD Impacts Found on a Returned ISS Cover

J. HYDE, J. READ, D. LEAR, AND E. CHRISTIANSEN

Twenty-six (26) micrometeoroid and orbital debris (MMOD) impact features were found on a returned cover from the International Space Station (ISS). The cover was exposed to MMOD impacts for 1.63 years (from July 2013 to February 2015) before it was returned on the SpaceX CRS-6 mission. It was located at the forward port on ISS pressurized mating adapter 2 (PMA-2), as shown in Figure 1. The cover is a 2-m-diameter multilayer blanket with a beta-cloth exterior surface, which is a Teflon coated glass fabric.

The inspection team consisted of JSC Hypervelocity Impact Technology (HVIT) group and Boeing/Houston personnel (shown in Figures 2 and 3). The damages were found on the cover itself as well as straps that were used to hold the cover in place on PMA-2 (Figures 4 and 5).

Table 1 lists the 10 largest damages found in the inspection and Figure 6 shows a histogram of all damages. The largest damage left a 1.2-mm-diameter hole in the external beta-cloth layer of the cover. None of the damages completely penetrated the cover, which has a mass per unit area of 0.46 g/cm^2.

The next steps in the inspection will be to determine how deep the damages extend into the cover and to collect samples for examination in the analytical laboratories at JSC to determine, if possible, the composition of the impacting particle. In addition, a comparison will be made between the observed damage and predicted damage using the latest MMOD environment models and damage equations for the cover, based on impact test data. ♦

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MMOD Impacts

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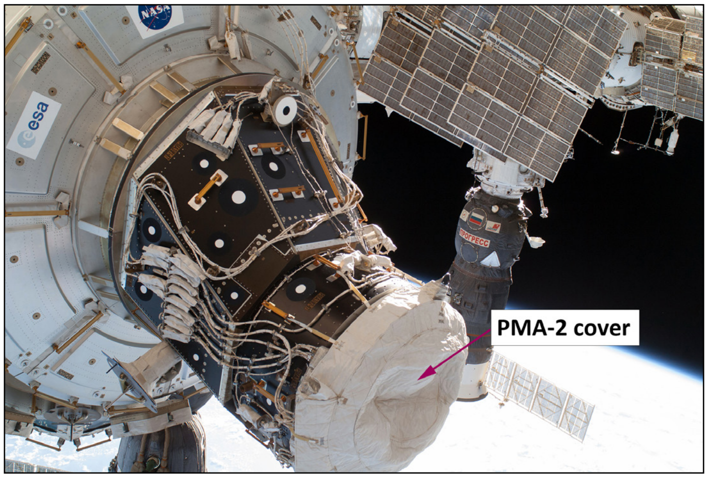

Figure 1. The cover was exposed to MMOD for 1.63 years at the forward end of PMA-2.

Figure 2. NASA and Boeing personnel inspected the cover for visible damages and located 26 likely MMOD impact sites.

Figure 3. A 3-D digital scanning microscope mounted to an adjustable arm was used to photograph and measure the damage.

Figure 4. An overview of the cover including small labels indicating the location of each impact damage found in the inspection.

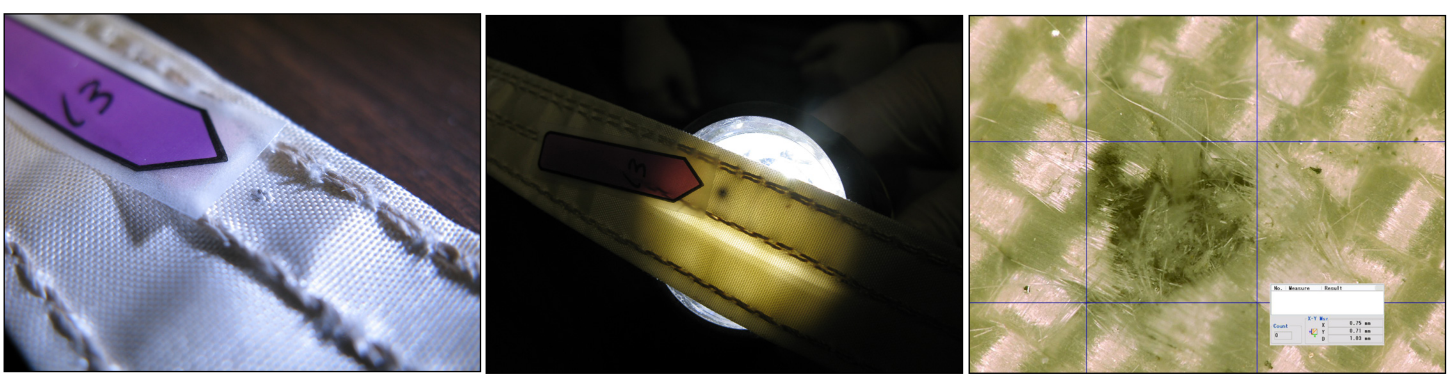

Figure 5. An impact damage (no.13) that was found on one of the hold-down straps. This damage is shown in front-light on left, back-light in middle, and through the microscope on right. The hole diameter in the outer beta-cloth layer was 0.75 mm although the dark zone in the back-lighted photo extended well beyond the hole dimensions.

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MMOD Impacts

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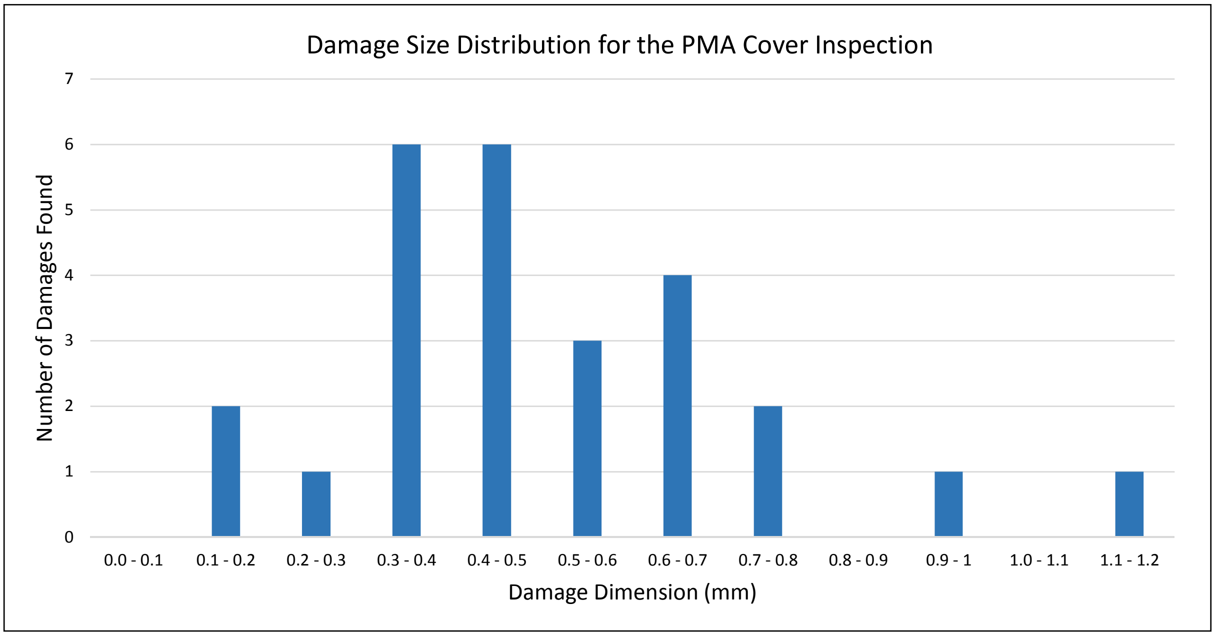

Figure 6. Damage Size Distribution for the PMA cover inspection. The number of damages found in each size bin is given in this graphic (for instance, six damages that were greater than 0.3 mm but less than 0.4 mm were found).

Fiftieth Anniversary of Apollo Program Fragmentation

July 2016 marks the 50th anniversary of a unique debris event that also marked a significant engineering milestone in mankind's *first* exploration of the Moon. The event was the launch of NASA's AS-203 mission, sometimes referred to as SA-203. This launch was the second launch of the Saturn 1B vehicle, whose second stage was the Douglas Saturn IVB cryogenic stage. Also lofted were an IBM Saturn V Instrument Unit and an aerodynamic fairing; though not technically a "payload," the stage also carried the maximum load of liquid hydrogen propellant. The primary engineering objective included testing the S-IVB engine restart on-orbit (necessary for the trans-lunar injection burn), the hydrogen continuous venting system, the evaluation of the engine chill-down and recirculation system, and observations of hydrogen fluid dynamics. The S-IVB stage was a cylinder of 28.3 m length overall and 6.6 m in diameter, with a dry mass of 26552 kg. A significant engineering feature of the stage was the decision to incorporate a common bulkhead between the liquid hydrogen fuel and liquid oxygen oxidizer tanks—the bulkhead contributed substantially to reducing both the length of the stage and its dry mass. Also pioneered was internal cryogenic insulation, in contrast to the external insulation panels employed by the contemporary cryogenic Centaur upper stage.

The launch occurred on 5 July 1966 at 2111 GMT. On orbit, the stage (International Designator 1966-059A, SSN # 2289) coasted and demonstrated restart capability as well as successfully completing other engineering tests. During the fourth and fifth revolutions, a deliberate differential pressure test of the stage's common bulkhead was conducted. The test closed the hydrogen vents while continuing to vent the liquid oxygen tank. The pressure differential, in excess of 23.7 N/cm^2, exceeded structure design limits and the stage broke up.

The event is estimated to have occurred while the stage was in an orbit of 214 x 185 km altitude at an inclination of 31.98° over an approximate location of 20° N latitude, 277° E longitude. Debris

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AS-203 launch; orbital vehicle above the black/white vertically-striped interstage structure.

Apollo Program Fragmentation

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was first observed by the Trinidad ground station, with the first object being cataloged on 6 July and the remainder between 8-12 July, 1966. In total, the stage remnant and 34 additional debris fragments were cataloged. All had reentered by 22 July.

It is interesting to discuss this ultimately destructive engineering test against current U.S. Government (USG) Orbital Debris Mitigation Standard Practices and those of the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines. Given that the stage was operational with three-axis attitude control and stored energy aboard, the USG standard practice “Objective 1” applies: Control of debris released during normal operations. In this case, debris created exceeded the 5 mm lower size threshold of the Objective, but the altitude at which the event occurred ensured that any debris produced would be very short-lived. In this sense, the AS-203 mission met the current Objective. The mission could also be justified on the basis of cost effectiveness and Saturn programmatic requirements. The IADC guideline 5.1 “Limit Debris Released during Normal Operations” states “… any release of debris should be minimized in number, area and orbital lifetime.” The minimal lifetime of the AS-203 met this guideline with minimal risk to other resident space objects. The low altitude at which the mission was conducted also ensured compliance with guideline 5.2.3 “Avoidance of intentional destruction and other harmful activities.” Specifically, “… intentional break-ups should be conducted at sufficiently low altitudes so that orbital fragments are short lived.” Thus, the AS-203 mission would be deemed compliant with today’s USG and international standard debris mitigation best practices. If done today, a test of this type would require considerable programmatic justification and preflight analysis. ♦

UPCOMING MEETINGS

30 July - 7 August 2016: 41st Committee on Space Research (COSPAR) 2016, Istanbul, Turkey

The 41st Committee on Space Research (COSPAR) Assembly will convene in Istanbul’s Congress Center on Saturday, 30 July 2016 and run through Sunday, 7 August. The COSPAR panel Potentially Environmentally Detrimental Activities in Space (PEDAS) will conduct a program entitled “Space Debris – Providing the Scientific Foundation for Action.” PEDAS.1 sessions will include advances in ground- and space-based measurements of the orbital debris environment, micrometeoroid and orbital debris environment modeling, risk assessment, mitigation and remediation, hypervelocity impact range developments, and protection. Please see the COSPAR website at https://www.cospar-assembly.org/ and the Assembly website http://cospar2016.tubitak.gov.tr/ for further information.

6-11 August 2016: 30th Annual AIAA/USU Conference on Small Satellites, Logan, Utah (USA)

Utah State University will host the 30th Annual AIAA/USU Conference on Small Satellites at the Taggert Student Center in August 2016. In addition, the pre-conference 13th Annual Summer CubeSat Developer’s Workshop will be conducted on 6-7 August. The conference program considers all aspects of small satellite development and deployment, and reviews the past 18 months of smallsat launches and previews the next 18 months. Please see the conference website at http://www.smallsat.org/index for further information.

20-23 September 2015: 17th Advanced Maui Optical and Space Surveillance Technologies Conference, Maui, Hawaii (USA)

The technical program of the 17th 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 Orbital Debris, Space Situational Awareness, Adaptive Optics & Imaging, Astrodynamics, Non-resolved Object Characterization, and related topics. Additional information about the conference is available at http://www.amostech.com.

26-30 September 2016: 67th International Astronautical Congress, Guadalajara, Mexico

The Mexican Space Agency, Agencia Espacial Mexicana (AEM), will host the 67th IAC Conference with a theme of "Making space accessible and affordable to all countries." The 2016 Congress will include the 14th International Academy of Astronautics (IAA) Symposium on Space Debris 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://iac2016.org.

SATELLITE BOX SCORE

(as of 5 July 2016, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	215	3564	3779
CIS	1509	4809	6318
ESA	69	53	122
FRANCE	62	467	529
INDIA	70	112	182
JAPAN	154	90	244
USA	1384	4279	5663
OTHER	779	113	892
TOTAL	4242	13487	17729

Visit the NASA Orbital Debris Program Office Website

www.orbitaldebris.jsc.nasa.gov

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INTERNATIONAL SPACE MISSIONS

31 March 2016 – 30 June 2016

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2016-022A	PROGRESS-MS-02	RUSSIA	402	404	51.6	1	0
2016-023A	SJ-10	CHINA	254	267	42.9	1	3
2016-023E	SJ-10 MODULE	CHINA	131	140	42.9		
2016-024A	DRAGON CRS-8	USA	402	405	51.6	0	2
2016-025A	SENTINEL 1B	ESA	695	697	98.2	0	0
2016-025B	MICROSCOPE	FRANCE	712	713	98.2		
2016-025C	OUFTI-1	BELGIUM	441	686	98.2		
2016-025D	E-STAR-2	ITALY	441	686	98.2		
2016-025E	AAUSAT 4	DENMARK	441	685	98.2		
2016-025F	ASAP-S	FRANCE	439	692	98.2		
2016-026A	MVL 300	RUSSIA	468	487	97.3	2	0
2016-026B	AIST 2D	RUSSIA	468	487	97.3		
2016-026C	SAMSAT 218D	RUSSIA	467	484	97.3		
2016-027A	IRNSS 1G	INDIA	35779	35798	5.0	1	0
2016-028A	JCSAT-14	JAPAN	35776	35797	0.0	1	0
2016-029A	YAOGAN 30	CHINA	626	658	98.1	0	0
2016-030A	GALILEO 14 (26B)	ESA	23269	23276	57.4	1	0
2016-030B	GALILEO 13 (26A)	ESA	23216	23229	57.4		
2016-031A	THAICOM 8	THAILAND	35772	35802	0.0	1	0
2016-032A	COSMOS 2516 (GLONASS)	RUSSIA	19102	19158	64.8	1	0
2016-033A	ZY 3 2	CHINA	501	503	97.5	1	0
2016-033B	NUSAT 1	ARGENTINA	479	500	97.5		
2016-033C	NUSAT 2	ARGENTINA	480	501	97.5		
2016-034A	COSMOS 2517 (GEO-IK)	RUSSIA	938	961	99.3	1	0
2016-035A	INTELSAT 31	INTELSAT	35776	35797	0.1	1	1
2016-036A	USA 268	USA	NO ELEMS. AVAILABLE			1	0
2016-037A	BEIDOU G7	CHINA	35776	35798	1.8	1	0
2016-038A	ABS 2A	BERMUDA	EN ROUTE TO GEO			1	0
2016-038B	EUTELSAT 117W B	EUTELSAT	EN ROUTE TO GEO				
2016-039A	BRISAT	INDONESIA	35781	35793	0.1	1	1
2016-039B	ECHOSTAR 18	USA	35776	35797	0.1		
2016-040A	CARTOSAT 2C	INDIA	500	519	97.5	1	1
2016-040B-V	(19 additional small sats.)						
2016-041A	MUOS 5	USA	EN ROUTE TO GEO			1	0
2016-042B	AX-1	CHINA	284	373	40.8	2	6
2016-042D	REENTRY SHROUD	CHINA	158	197	40.8		
2016-042F	AL-1	CHINA	198	367	40.8		
2016-042L	TIANGE 1	CHINA	277	286	40.8		
2016-042M	TIANGE 2	CHINA	276	288	40.8		
2016-043A	SJ 16-02	CHINA	596	616	75.0	1	0

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