National Aeronautics and Space Administration

Orbital Debris Quarterly News

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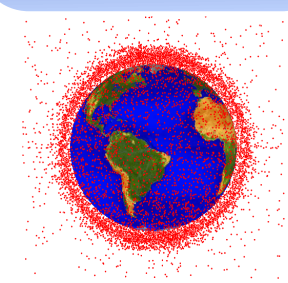
Inside...



A publication of the NASA Orbital Debris Program Office

International Space Station Performs Fourth and Fifth Debris Avoidance Maneuvers of 2014

On 27 October 2014, the International Space Station (ISS) performed a maneuver to avoid the close approach of debris from the 2009 collision of Iridium 33 and Cosmos 2251. In this case, Cosmos 2251 debris (International Designator 1993-036ACU, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog number 34881) was identified as passing within approximately 4 km of the ISS, with a time of closest approach (TCA) of 20:13 UTC. The small fragment displays an average characteristic diameter of approximately 8 cm.

The maneuver burn was performed by the European Space Agency (ESA) Automated Transfer Vehicle no. 5 (ATV-5), *Georges Lemaître*. Ground teams commanded a pre-determined debris avoidance maneuver (PDAM) and the ATV-5 performed a 4-minute thrust at 17:42 UTC, with a total Δv of 0.5 m/s, sufficient to raise the ISS by 1 km and thereby avoid the conjunction.

The ATV-5 executed a second PDAM on 12 November 2014 at 12:20 UTC to eliminate a repeating conjunction concern, the TCA of most concern being at 14:40 UTC. The threat was posed by mission-related debris (2001-066G, SSN# 39372), from Yaogan 12, launched by the People's Republic of China. The debris is estimated to be approximately 14 cm in diameter. This PDAM had the added benefit of obviating a pre-planned ISS orbit reboost to have been performed by the ATV-5 later that day.

The PDAM capability allows ground teams to implement a generic, 0.5 m/s debris avoidance maneuver as late as TCA – 3 hours, depending upon

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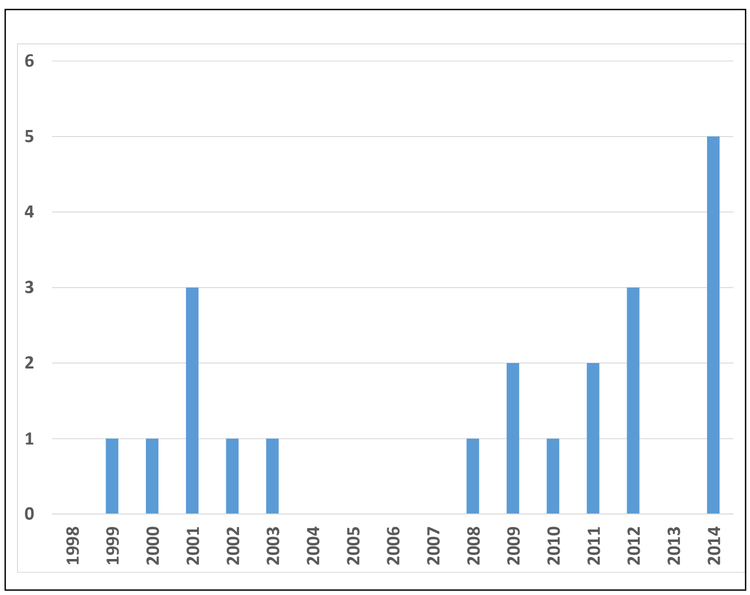

This figure depicts the occurrences of debris avoidance maneuvers since the launch of the first module, Zarya, in 1998. The reader is cautioned that the number of maneuvers per year does not lend itself to a single, simple interpretation; rather, the number depends upon Poisson statistical, environmental, and operational factors.

Avoidance Maneuvers

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ISS configurations. In this case, the maneuver would commence at TCA – 140 minutes ± 15 minutes. Mission analysts verify that the PDAM does not inadvertently increase collision risk subsequent to a maneuver. The capability of performing an ATV PDAM was introduced on ATV-4 *Albert Einstein* but not used, and provided redundancy to using either the ISS *Zvezda* module's onboard thrusters or docked Russian Progress vehicles for ISS maneuvers. The ATV-5, the heaviest Ariane 5 launch to date, is the last ESA supply vehicle.

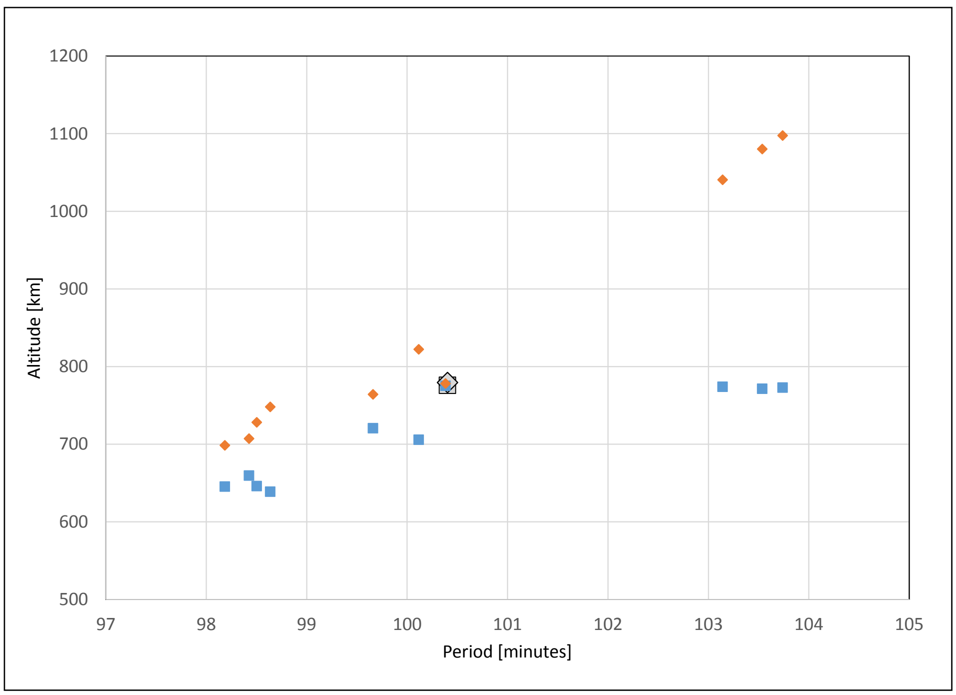
These maneuvers were the 20th and 21st overall since 1999 and the fourth and fifth of 2014.

Note: The ATV-5 is named after Professor Georges Lemaître (1894-1966), the Belgian physicist regarded as the father of the Big Bang theory. ♦

Iridium Anomalous Debris Events

The year 2014 saw two puzzling debris-producing events involving Iridium satellites. Neither produced a large number of debris, but both illustrate how mysterious many of the debris phenomena in Earth orbit still remain.

The first event was a breakup of Iridium 47 (International Designator 1997-082C, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog number 25106, launched 20 December 1997). On 7 June 2014, this spacecraft produced 10 pieces of debris that are currently tracked and catalogued by the U.S. Joint Space Operations Center (JSpOC). As can be seen in the figure, some of these pieces were created with considerable delta-velocity – in one case exceeding 80 meters per second. According to Iridium Communications Inc., the parent spacecraft continued to function normally and did not show any obvious changes in its orbit at the time of breakup.



A Gabbard diagram of the Iridium 47 breakup. Hollow symbols indicate payload orbit. In this Gabbard diagram, red and blue symbols denote a given object's apogee and perigee altitudes, respectively.

The second breakup was of Iridium 91 (2002-005A, #27372, launched 11 February 2002). On 30 November 2014, the spacecraft produced four pieces of debris that are currently tracked and catalogued by JSpOC. Like Iridium 47, the operators of the spacecraft report that the spacecraft continues to function normally, and did not show any obvious changes in its orbit at the breakup time. In contrast to the previous Iridium breakup, however, these pieces were produced with minimal delta velocity and remained in the vicinity to the parent spacecraft for some time.

Either or both of these events could have been due to collisions with small debris – collisions that did not result in noticeable momentum transfer. The Iridium 91 event could have simply been a sloughing off of insulation material that has been seen in other types of satellites before. The Iridium 47 event, however, clearly was due to some sort of high-energy event. In the absence of evidence of an explosion on board the spacecraft, a collision with a piece of untracked debris is the most likely culprit. ♦

DRAGONS to Fly on the ISS

On 28 October 2014, the International Space Station (ISS) Program approved development of the *Debris Resistive Acoustic Grid Orbital Navy-NASA Sensor* (DRAGONS) as an experiment to fly on the ISS, possibly as early as October 2016. The DRAGONS is a calibrated impact sensor designed to directly measure the ISS orbital debris environment for 2 to 3 years.

The sensor will have about 1 m^2 of detection area mounted at an external payload site facing the velocity vector to maximize detections. As shown in Figure 1, it combines observation techniques to measure the size, speed, direction, time, and energy of small debris impacting the sensor. The front layer of DRAGONS is a thin film of Kapton with

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DRAGONS

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acoustic sensors and a grid of resistive wires. These acoustic sensors will measure the time and location of a penetrating impact, while a change in resistance on the grid when lines are broken will provide a size estimate of the hole. The relationship between object size and hole size will be determined by hypervelocity testing under controlled conditions at the White Sands Test Facility in New Mexico and at the University of Kent at Canterbury, UK.

Located 15 cm behind the first layer is a second thin layer of Kapton with acoustic sensors to measure the time and location of the second penetration. Velocity is determined by dividing the distance travelled between the first and second impact points by the time it took to travel that distance. An instrumented back layer will stop the debris and measure the amount of energy in the collision. With energy (E) and velocity (v), we can solve for mass (m) in the equation: $E = \frac{1}{2} m * v^2$. Finally, the density of the object can be estimated if we assume that the object volume is about the same as a sphere with a diameter determined from the hole size. Density is an important feature of debris because an object made of steel (7.9 g/cc) will do more damage than a similarly sized piece of aluminum (2.8 g/cc).

The DRAGONS should be able to detect debris as small as 50 microns and will collect statistics on objects below 1 mm, illustrated in Figure 2. Results from this experiment will update information previously obtained by inspecting hardware returned from space by the Space Shuttle. This flight demonstration will also prove the viability of the technology for future missions at higher altitudes where risks from debris to spacecraft can be greater than at the ISS altitude.

The decision by the ISS Program to fund and fly DRAGONS marks a major milestone in the history of the project. The DRAGONS team includes the NASA Orbital Debris Program Office, the NASA Hypervelocity Impact Technology group, the NASA/JSC Engineering Directorate, Jacobs, the United States Naval Academy, the Naval Research Lab, Virginia Tech, and the University of Kent. See our previous article on DRAGONS in ODQN, vol. 16, issue 3, July 2012, pp. 2-3 <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv16i3.pdf>. ♦

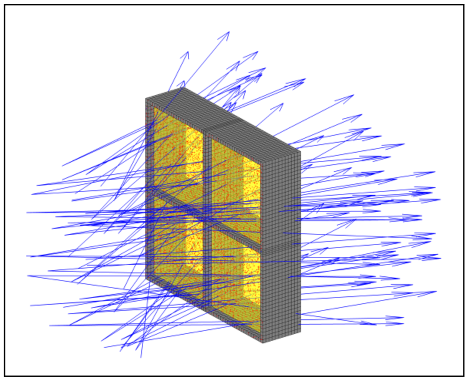

Figure 1. The DRAGONS will use observation techniques, acoustic sensors, and a grid of resistive wires to directly measure the ISS OD environment.

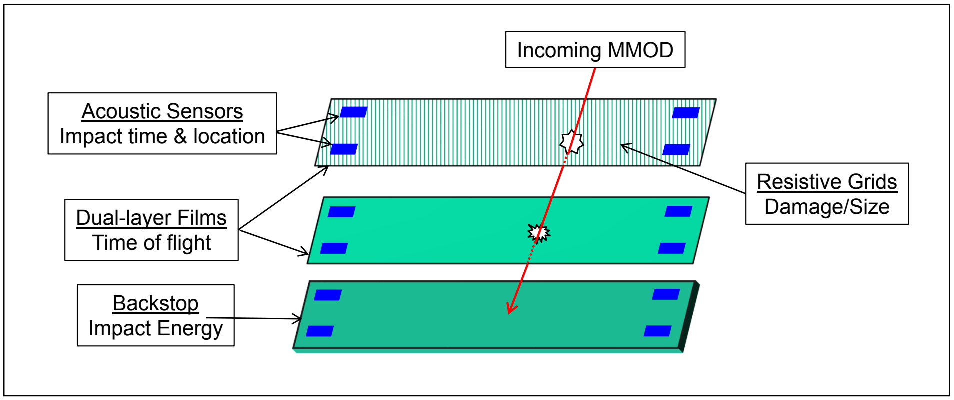

Figure 2. A preliminary concept drawing of the sensor, which illustrates how debris as small as 50 microns will pass through. The ISS DRAGONS will collect statistics on objects below 1 mm.

UKIRT Extends OD Observations into the Infrared Regime

In 2014, NASA's Orbital Debris Program Office (ODPO) gained access to the United Kingdom Infrared Telescope (UKIRT) for orbital debris research. Lockheed Martin Space Systems was awarded a NASA contract to assume operations of this extremely productive telescope with the University of Arizona. An unprecedented one-third of this telescope's time has been allocated for the NASA ODPO Optical Measurements Group (OMG) to collect orbital debris data over a 2-year period. This new asset increases the spectral and geographical coverage of geosynchronous orbital debris objects available to the OMG.

UKIRT is a 3.8 m telescope located on Mauna Kea, Hawaii (Figure 1). At nearly 14,000 feet, this location is one of the premier astronomical sites due to its altitude, exceptionally dry air (often 5-10% humidity or lower) and distance from light pollution.

Using UKIRT's five available instruments, the ODPO's spectral coverage extends into the

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Figure 1. The UKIRT facility (left) is home to a 3.8 m infrared telescope (right). Photos courtesy of Tom Kerr (facility) and Paul Hirst, (telescope), Joint Astronomy Centre.

UKIRT

continued from page 3

near- (0.8-5 μm) and the mid- to far-infrared (8-25 μm) regimes (Figure 2). Analysis of low- and high-resolution spectroscopy as well as photometry yields insights into the reflectance properties of debris across these wavelengths, useful for characterizing the physical properties of objects. Absorption bands in spectra can be used to infer materials comprising debris targets, while combining reflected and thermal IR responses leads to estimates of an object's size. The combination of all these capabilities is critical for understanding the threat debris poses to active satellites.

The combination of this ground-based telescope with optical telescopes, including the Meter Class Autonomous Telescope (MCAT) on Ascension Island (under construction) and telescopes in Chile, yields spectral coverage ranging from 0.3 – 25 μm (Figure 3). Through access to these telescopes, orbital debris is now being studied in depth across a wider wavelength range in the visible and IR than ever previously studied by ODPO. When combined with either catalogued or simultaneously obtained visible photometry, changes in the objects' albedo across the electromagnetic spectrum will provide further insight into material types and sizes. By expanding the methods for surveying, detecting, and characterizing orbital debris, we can better model the debris environment and ultimately gain insight into how to mitigate potential collisions for future missions [1].

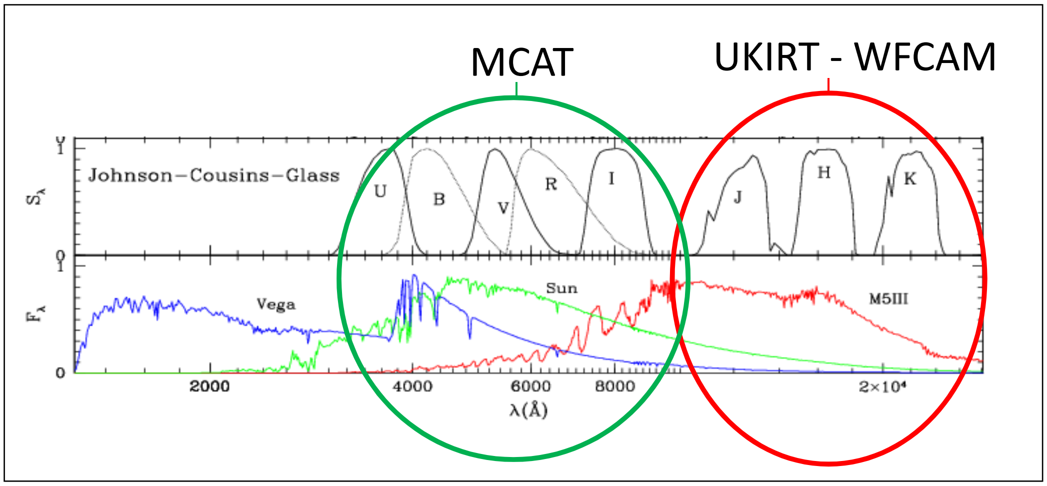

Figure 2. Spectra of a blue star (Vega), the Sun, and a red star (M5III) compared with visible-band Johnson-Cousins filters (circled in green), to be used by MCAT, and infrared bands (circled in red), in use at UKIRT. Comparisons of albedo estimates in both the optical and near infrared will help constrain material estimates of observed debris objects. Image adapted from Giaradi 2002 et al. (Astronomy and Astrophysics, v.391, p.195-212.).

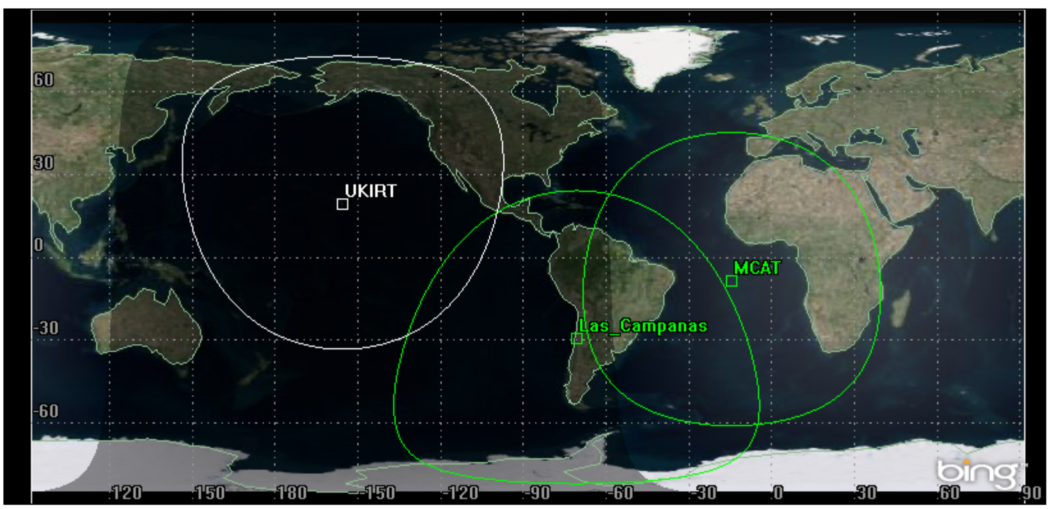

Figure 3. Fields of regard for observatories used by NASA's ODPO, including UKIRT on Mauna Kea, Las Campanas Observatory in Chile, and the MCAT, currently under construction on Ascension Island. UKIRT will provide extended longitudinal coverage of the GEO-belt and expand wavelength coverage from the optical into the infrared.

Reference

1. Lederer, S., *et al.* NASA's Newest Orbital Debris Ground-based Telescope Assets: MCAT and UKIRT, 2014 *AMOS Technical Conference Proceedings,* 2014. ♦

Korean Aerospace Research Institute Joins IADC

The Inter-Agency Space Debris Coordination Committee (IADC) is an international governmental forum for the worldwide coordination of activities related to the issues of human-made and natural debris in space. IADC members are countries or national or international space organizations that carry out space activities, either through manufacturing, launching, and operating spacecraft, or manufacturing and launching rockets. The IADC has accepted the Korean Aerospace Research Institute (KARI) of the Republic of Korea as the thirteenth member of the organization.

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,

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KARI

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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. The Canadian Space Agency joined the IADC in 2010, followed by KARI in 2014.

The IADC is the internationally recognized technical authority on space debris. Its website (www.iadc-online.org) offers numerous resource materials on space debris, as well as many technical reports and documents produced by the committee. The IADC issued the first comprehensive international set of space debris mitigation guidelines in 2002. These guidelines became the foundation of the United Nations (UN) Space Debris Mitigation Guidelines, which were endorsed by the UN General Assembly in 2007. ♦

Fiftieth Anniversary of First Intentional Fragmentation Event in Space

November 2014 marked the 50th anniversary of the deliberate destruction of Cosmos 50. Cosmos 50 (International Designator 1964-070A, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog #919), a Zenit-2 low-resolution photoreconnaissance spacecraft, fragmented into at least 94 cataloged pieces on 5 November 1964 following a payload recovery failure. This is regarded as the first deliberate destruction of a spacecraft by its operator [1].

From 1962 to 1970, Zenit-2 class spacecraft, similar to the *Vostok* spacecraft, conducted photographic reconnaissance for military and civilian purposes and returned the exposed film to Earth for processing and analysis. Spacecraft system failures, which would prevent the successful guided reentry and recovery of the payload module within the territory of the former Soviet Union, were anticipated. The spacecraft were equipped with the *avareynogo podrava obyecta* (APO) self-destruct system [2]. This system contained 10 kg or more of TNT or similar explosive and was located within the payload module as shown in Figure 1.

The Cosmos 50 APO system was activated following failure of the TDU-1 liquid deorbit engine [2]. While analyses indicate that several hundred pieces could result from a fragmentation of this type, the low altitude of the event complicated tracking, pass-to-pass correlations, and cataloging by the SSN [3]. The 94 cataloged objects are assessed to have reentered Earth's atmosphere by 17 November 1964, posing no long-term hazard to other spacecraft.

Historically, the self-destruction of spacecraft became a major contributor to the number of breakups of known cause. Usually associated with payload recovery failures, on-orbit weapons tests, or mission termination events, 52 events spanned the decades from Cosmos 50 to the Cosmos 2423 event on 17 November 2006. Propulsion-related events, excluding the breakups of SOZ units (see ODQN, vol. 18, issue 4, October 2014, p. 1 and figures 1 & 2), only surpassed self-destruct events in number permanently with the 19 February 2007 breakup of a Briz-M upper stage.

References

1. Johnson, N.L., et al., History of On-orbit Satellite Fragmentations", 14th ed., NASA TM-2008-214779, 2008.

2. Agapov, V., "Zapuski kosmichieskikh appratov 'Zenit-2'", *Novosti Kosmonavtiki*, Vol. 6, No. 10, 1996.

3. Johnson, N.L., and Chernyavskiy, G.M. "History of Soviet/Russian Satellite Fragmentations – A Joint US-Russian Investigation," Kaman Sciences Corp., 1995. ♦

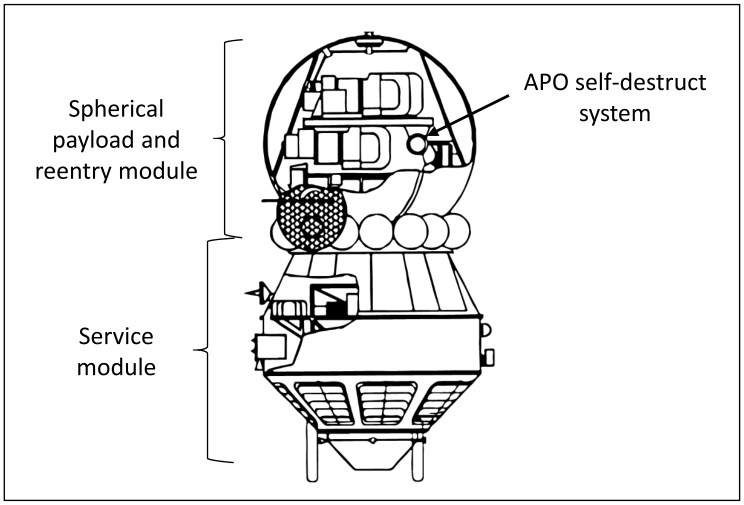

Figure 1. A Zenit-2 spacecraft with cutaway; APO system as indicated within the payload module/reentry vehicle (adapted from reference 3; from reference 2).

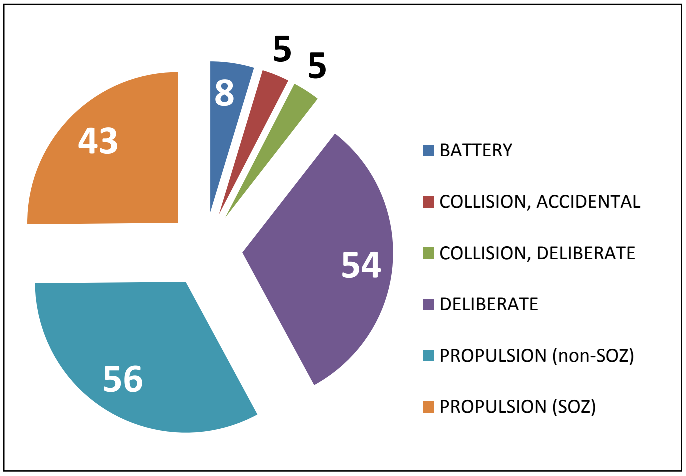

Figure 2. Standard breakups of known cause, as of December 2014. Included in this count of deliberate fragmentations (54) are the breakups of Cosmos 248 and a Saturn S IVB upper stage.

PROJECT REVIEW

Solar Cycle Sensitivity Study of Breakup Events in LEO

A. B. VAVRIN

Atmospheric drag, governed by solar flux activity, is usually the most important factor in determining orbital lifetime of uncontrolled objects in Low Earth Orbit (LEO) to Geosynchronous Transfer Orbit (GTO). Short-term projections in solar flux activity are developed by the National Oceanic and Atmospheric Administration Space Environment Center (NOAA/SEC) and typically extend through the end of the current cycle. Long-term projections in solar flux activity developed by the NASA Orbital Debris Program Office (ODPO) are used to extend the daily historical flux values and projection beyond the current cycle. Observed solar flux activity shows that the current solar cycle has entered a period of lower solar flux intensity than previously forecasted. This study examines the sensitivity of calculating the orbital lifetime predictions of LEO breakup clouds (specifically the Fengyun 1-C and Iridium 33/Cosmos 2251 breakup events) based on two cases. The first case uses daily variations in solar flux using the NASA-only average flux predicted in 2009. The second case uses actual measured values up through 2013 and the NOAA flux projection up to the end of the current cycle. The solar flux predictions for these years are compared in Figure 1.

The 2007 FY-1C breakup event and the 2009 collision between Cosmos 2251 and the operational Iridium 33 introduced new debris fragments into the LEO environment. The addition of these breakup clouds increases the risk of future impacts in an already highly populated altitude region, as seen in the spatial density distribution graph in Figure 2. Modeling future behavior of these debris clouds has become important to understanding risk in the LEO population.

The primary tool used by the NASA ODPO for orbital lifetime prediction in the LEO to GTO region is PROP3D, which was designed specifically for long-term orbital debris evolutionary models such as EVOLVE and LEGEND (LEO-to-GEO Environment Debris model). PROP3D accounts for the effects of all significant orbital perturbing forces and uses integration schemes focused on maintaining integration accuracy over propagation periods of many decades with reasonable computation speed. PROP3D includes the following perturbing forces that are required to simulate the three-dimensional orbital population adequately: atmospheric drag induced by an oblate and rotating model atmosphere, solar and lunar gravitational perturbations, solar radiation pressure, Earth's shadow effects, as well as Earth's gravity-field zonal harmonics J_2, J_3, J_4, and J_{22} (ODQN, vol. 18, issue 1, January 2014, p. 1).

As solar flux activity can be one of the most important factors in determining orbital lifetime, and consequently the number of objects in orbit, a table of daily solar flux values is the primary input into PROP3D [1]. The solar flux table combines historical measured daily flux values (1957 to present), short-term flux forecasts (available through the NOAA/SEC), and ODPO predicted future flux values of up to 200 years based upon the historic measurement data. The NOAA prediction was not included in this process until the beginning of the most recent cycle (ODQN, vol. 13, issue 1, January 2009, p. 7). The September 2009 solar flux table contains measurement data points up to 2007 with ODPO predicted future flux values from 2007 to 2009. For epochs up to the end of the current solar cycle, a curve-fit technique using sixth order sine and cosine terms is performed to fit historical daily solar flux values. This curve-fit equation is then used to generate future flux predictions. The fitting technique simultaneously determines 14 coefficients, which includes 12 sine/cosine terms, the average period, and a constant average flux term. The form of the fitting curve forces the solution to have a single average periodicity representing an average value over the data set used. The current value of this base period is 3900 days (10.7 years). The curve fit of the solar flux is the same for each cycle, with no attempt to predict high and low cycles and

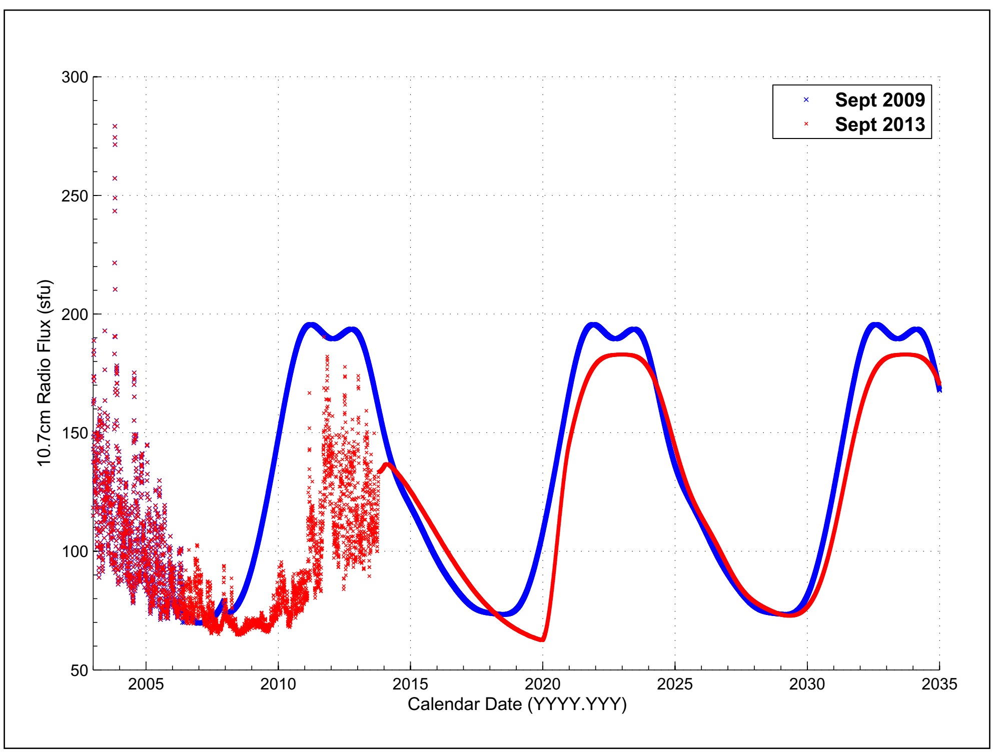

Figure 1. Solar Cycle F 10.7 cm Radio Flux data comparison of September 2009 and September 2013.

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Solar Cycle Sensitivity

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no weighting (ODQN, vol. 10, issue 2, April 2006, p. 4). Updates to these solar flux tables occur on a semi-annual basis. Announcements are published in the ODQN and via email to the list of Debris Assessment Software (DAS) update subscribers. It is available for download as a supporting text file to DAS on the NASA ODPO website.

Figure 3 shows the projected lifetime of the breakup clouds. The red solid line depicts the orbital lifetime of FY-1C breakup fragments (greater than or equal to 10 cm) calculated with the September 2009 solar flux table. The red dashed line reflects the orbital lifetime of fragments calculated with the September 2013 solar flux table. At the end of 2035, both solid lines show that the percentage of debris in orbit falls below 25% for > 10 cm objects of the original, modeled debris cloud. However, when calculating orbital lifetime using the September 2013 solar flux table, the percentage of debris fragments remaining in orbit increases. Figure 3 also shows the projected orbital lifetime of the Cosmos 2251/Iridium 33 breakup fragments calculated from the September 2009 solar flux table (solid blue) and the September 2013 solar flux table (dashed blue). Because of the lower perigee altitude, the Cosmos 2251/Iridium 33 fragments will decay faster than the FY-1C breakup objects. This study projects the number of objects remaining in orbit in 2035 to be roughly 9%, or 184 objects (> 10 cm), of the initial breakup cloud fragments from 2009. When applying the newer solar flux table, the percentage left in orbit increases to 15%, or 299 objects (> 10 cm).

<u>Reference</u>

1. Liou, J.-C., Hall, D.T., Krisko, P.H., and Opiela, J.N., LEGEND – A three-dimensional LEO-to-GEO debris evolutionary model. Adv. Space Res. 34, 5, pp. 981-986, 2004.

To view and/or download referenced issues of the ODQN, visit: <http://orbitaldebris.jsc.nasa.gov/newsletter/newsletter.html>. ♦

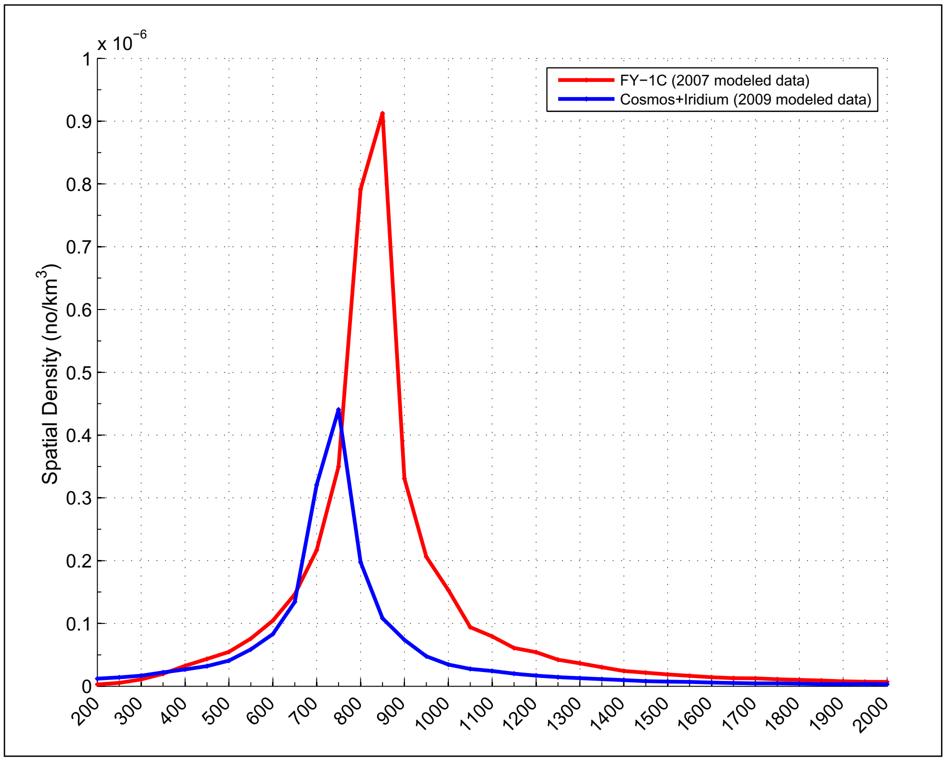


Figure 2. Spatial density distribution over altitude of the debris fragments for the FY-1C and the Cosmos 2251/Iridium 33 breakup events, >1 cm, 50 km bins.

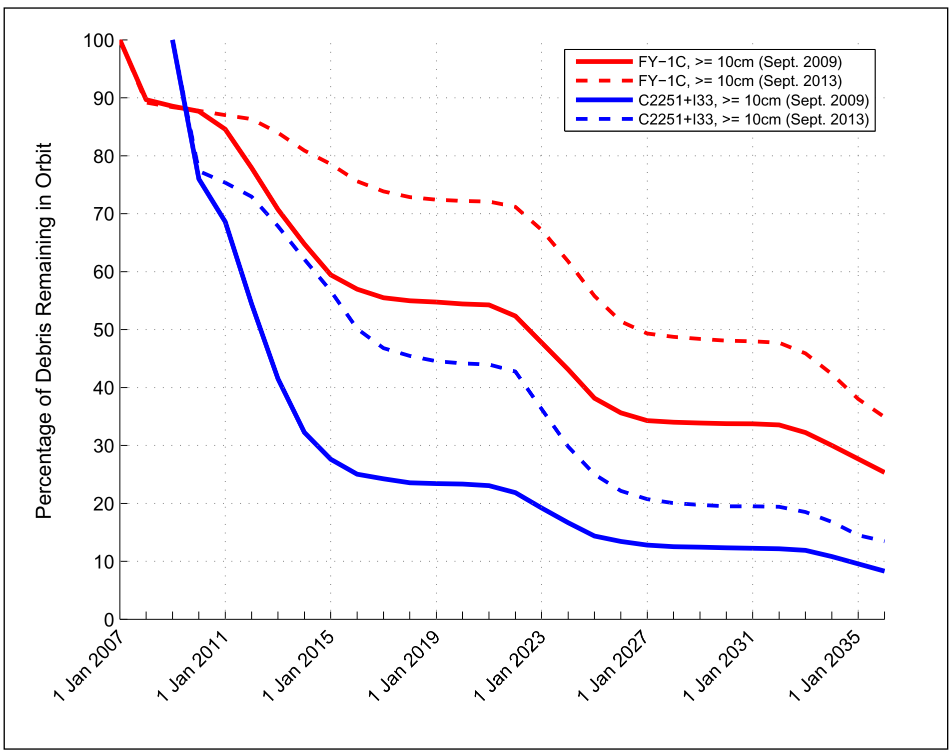


Figure 3. Percentage of debris remaining in orbit, for the FY-1C and the Cosmos 2251/Iridium 33 breakup events, from 1 January 2007 to 31 December 2035.

CONFERENCE AND WORKSHOP REPORTS

The 12th International Academy of Astronautics (IAA) Symposium on Space Debris (at the 65th International Astronautical Congress [IAC]), 29 September - 03 October 2014, Toronto, Canada

The 12th IAA Symposium on Space Debris was held during the 2014 IAC in Toronto, Canada. The Symposium addressed the complete spectrum of technical issues of space debris, ranging from measurements, modeling, risk assessment in space and on the ground, reentry, hypervelocity impacts and protection, mitigation and standards, to space situational awareness and surveillance. The Symposium consisted of nine oral sessions and one poster session, including more than 70 oral presentations and 40 posters. One of the sessions, A6.8, "Policy, Legal, Institutional and Economic Aspects of Space Debris Detection, Mitigation, and Removal" was a joint session with the Space Security Committee. The poster, *"Ground-based Optical Observation System for LEO Objects"* by Dr. T. Yanagisawa (JAXA) won the Best Poster Award during the conference. Overall, the Symposium brought subject matter experts from academia, government, and industry around the world together for focused, as well as cross-disciplinary, presentations and discussions on various aspects of space debris. It was a very successful event. More than 20 high quality papers were also selected and recommended for submission to *Acta Astronautica* by Session Chairs and Rapporteurs. ♦

The 7th International Association for the Advancement of Space Safety Conference (IAASS) 20-22 October 2014, Friedrichshafen, Germany

The 7th International Association for the Advancement of Space Safety (IAASS) conference was held 20-22 October in Friedrichshafen, Germany with the title "*Space Safety is No Accident*." Orbital debris was the topic of eight sessions and one panel discussion. In addition, orbital debris was addressed in a number of other sessions associated with aviation safety, launch safety, international policy, and a panel on planetary defense. Debris concerns associated with nano and pico satellites were highlighted early in the event as an aside to a keynote speech, and were the topic of discussion in a number of sessions and panels. For further information, visit the conference website at <http://iaassconference2014.space-safety.org>. ♦

The 6th International Association for the Advancement of Space Safety Conference (IAASS) Workshop on Public Safety of Launch & Reentry Operations 23-24 October 2014, Stuttgart, Germany

The 6th International Association for the Advancement of Space Safety (IAASS) Workshop on Public Safety of Launch & Reentry Operations, 23-24 October 2014, Stuttgart, Germany,

The 6th International Association for the Advancement of Space Safety (IAASS) Workshop on Public Safety of Launch & Reentry Operations was held 23-24 October in Stuttgart, Germany. The launch reentry workshop serves as the official meeting of the IAASS Launch and Reentry Safety Committee and was attended by representatives from the U.S. Federal Aviation Administration (FAA), NASA, the European Space Agency (ESA), and the space agencies of France (CNES), Germany (DLR), Japan (JAXA), and South Korea (KARI). The focus of this meeting was defining the terms of reference and structure of the committee as well as determining a roadmap for topics of collaboration including policy, analysis methods, and technical issues associated with launch and reentry safety. ♦

Center for Orbital Debris Education and Research (CODER) Workshop 18-20 November 2014, College Park, Maryland, USA

The University of Maryland's Center for Orbital Debris Education and Research (CODER) conducted a workshop at their College Park, MD campus 18-20 November 2014. The two and one-half day event included eight panel sessions on orbital debris Policy and Security Issues; Technology Issues; Debris Threats to Spaceflight and National Security; Debris Field Modeling and Simulation; Current Practices and Active Research; Remediation Architectures and Technologies; Entrepreneurial Opportunities; and Orbital Debris Research Priorities. ♦

Errata for ODQN "International Space Missions"

The ODQN 18-4 noted that there was one cataloged debris object associated with the International Designator 2013-076 (ODQN, vol. 18, issue 4, October 2014, p. 12). This object has been identified as Cosmos 2491, International Designator 2013-076E, SSN #39497. According to the Radio Amateur Satellite Corporation, AMSAT, it has activated an amateur radio payload, Radio Sputnik (RS) 46. An evidently similar spacecraft, International Designator 2014-028E, SSN #39765 ("OBJECT E" – see ODQN, vol. 18, issue 3, July 2014, p. 8) has been identified as Cosmos 2499; it also has activated an amateur radio payload, RS-47, after drawing considerable interest due to its demonstrated maneuver capability.

The payload 2014-058A ("OBJECT A" – see ODQN, vol. 18, issue 4, October 2014, p. 12) has been identified as Luch (Olymp). ♦

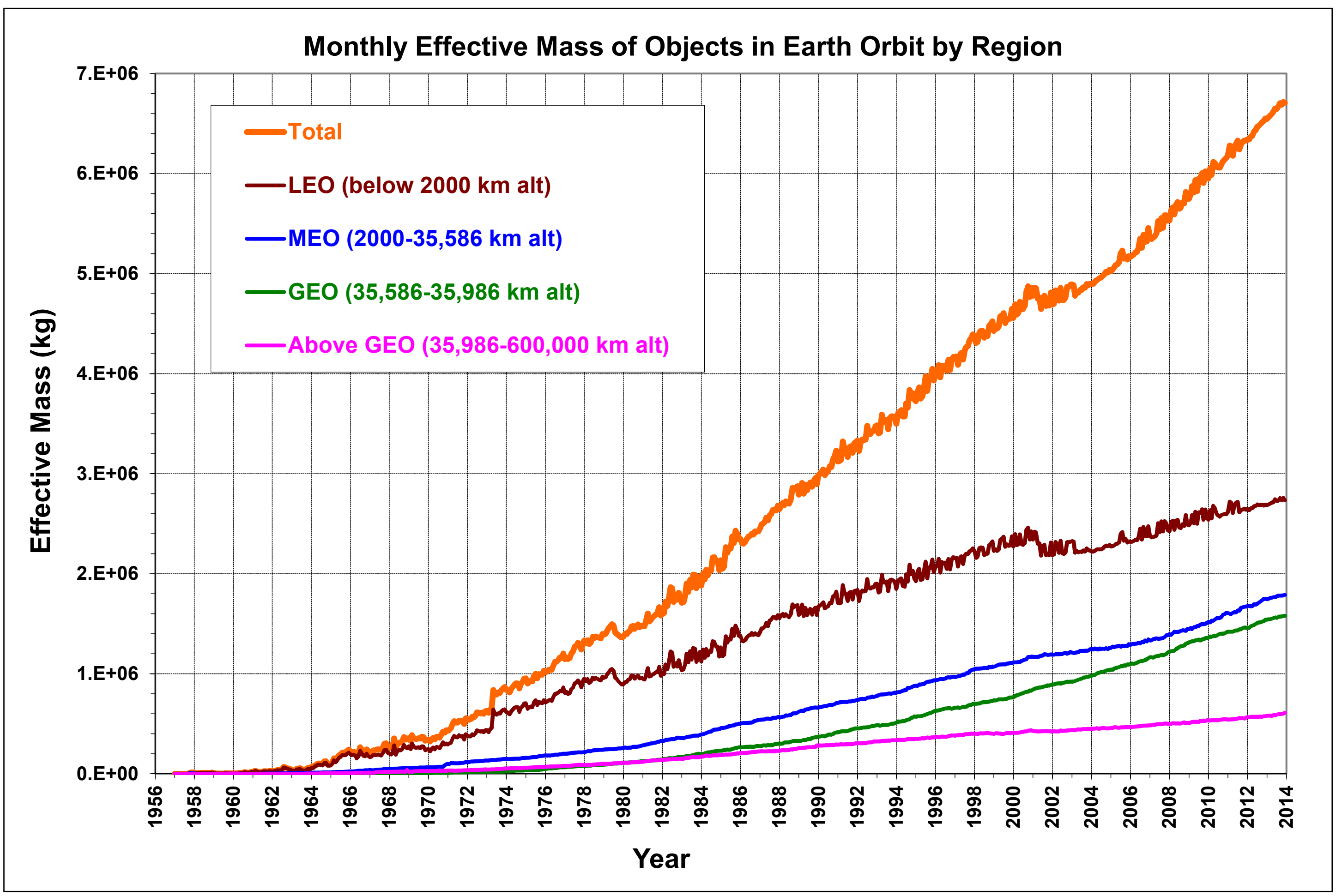
UPCOMING MEETINGS

4-10 July 2015: The 30th International Symposium on Space Technology and Science (ISTS), Kobe-Hyogo, Japan

The 30th ISTS will be a joint conference with the International Electric Propulsion Conference (IEPC) and the Nano-Satellite Symposium (NSAT). The 19 technical sessions planned for the 2015 ISTS include one on Space Environment and Debris. The abstract submission deadline is 20 November 2014. Additional information is available at: <http://www.ists.or.jp/2015/>.

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>.



Monthly Effective Mass of Objects in Earth Orbit by Region: This chart displays the mass of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. Divided into orbital altitude regions, "effective mass" accounts for the fraction of its orbit that an object may spend in the different regions.

SATELLITE BOX SCORE

(as of 31 December 2014, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	176	3580	3756
CIS	1455	4896	6351
ESA	50	46	96
FRANCE	60	447	507
INDIA	57	111	168
JAPAN	134	73	207
USA	1286	3752	5038
OTHER	663	120	783
TOTAL	3881	13025	16906

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INTERNATIONAL SPACE MISSIONS
1 October 2014 – 31 December 2014

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2014-060A	HIMAWARI 8	JAPAN	35782	35792	0.0	1	0
2014-061A	IRNSS 1C	INDIA	35690	35882	4.8	1	0
2014-062A	INTELSAT 30	INTELSAT	35775	35798	0.0	1	1
2014-062B	ARSAT 1	ARGENTINA	35780	35794	0.0		
2014-063A	YAOGAN 22	CHINA	1198	1207	100.3	1	0
2014-064A	EXPRESS AM-6	RUSSIA	33640	38068	0.5	1	1
2014-065A	CHANG'E 5-T1	CHINA	263	277	28.91	1	0
2014-066A	SJ-11-08	CHINA	687	704	98.2	1	4
2014-067A	PROGRESS-M 25M	RUSSIA	403	413	51.6	1	0
2014-068A	NAVSTAR 72 (USA 258)	USA	20156	20211	55.0	1	0
2014-069A	MERIDIAN 7	RUSSIA	957	39397	62.8	1	0
2014-070A	ASNARO	JAPAN	506	508	97.5	1	1
2014-070B	HODOYOSHI 1	JAPAN	503	522	97.5		
2014-070C	CHUBUSAT 1	JAPAN	503	535	97.5		
2014-070D	QSAT-EOS	JAPAN	502	549	97.5		
2014-070E	TSUBAME	JAPAN	503	564	97.5		
2014-071A	YAOGAN 23	CHINA	511	513	97.3	1	3
2014-072A	YAOGAN 24	CHINA	628	654	97.9	0	0
2014-073A	KUAIZHOU 2 (KZ-2)	CHINA	292	323	96.6	0	0
2014-074A	SOYUZ-TMA 15M	RUSSIA	403	413	51.6	1	0
1998-067FL	SPINSAT	USA	402	412	51.6	0	0
2014-075A	COSMOS 2501 (GLONASS)	RUSSIA	19083	19176	64.8	1	0
2014-076A	HAYABUSA 2	JAPAN	HELIOCENTRIC			1	0
2014-076B	SHIN'EN 2	JAPAN	HELIOCENTRIC				
2014-076C	DESPATCH (ARTSAT 2)	JAPAN	HELIOCENTRIC				
2014-076D	PROCYON	JAPAN	HELIOCENTRIC				
2014-077A	ORION EFT-1	USA	0	5795	28.8	1	1
2014-078A	GSAT 16	INDIA	35779	35792	0.1	1	1
2014-078B	DIRECTV 14	USA	35783	35791	0.0		
2014-079A	CBERS-4	CHINA	773	774	98.6	1	0
2014-080A	YAOGAN 25A	CHINA	1079	1089	63.4	1	2
2014-080B	YAOGAN 25B	CHINA	1078	1091	63.4		
2014-080C	YAOGAN 25C	CHINA	1108	1118	63.4		
2014-081A	USA 259	USA	NO ELEMS. AVAILABLE			0	0
2014-082A	YAMAL 401	RUSSIA	412	35524	47.7	0	0
2014-083A	O3B FM10	O3B	7838	7843	0.0	1	0
2014-083B	O3B FM11	O3B	7830	7838	0.0		
2014-083C	O3B FM12	O3B	7814	7836	0.0		
2014-083D	O3B FM9	O3B	7825	7839	0.0		
2014-084A	KONDOR E	SOUTH AFRICA	498	500	74.8	1	0
2014-085A	DUMMY SAT 2/BREEZE-M	RUSSIA	36155	39091	0.3	1	0
2014-086A	COSMOS 2502	RUSSIA	900	911	67.2	1	0
2014-087A	RESURS P2	RUSSIA	461	472	97.3	1	0
2014-088A	YAOGAN 26	CHINA	487	491	97.4	1	0
2014-089A	ASTRA 2G	LUXEMBOURG	EN ROUTE TO GEO			1	1
2014-090A	FENGYUN 2G	CHINA	EN ROUTE TO GEO			1	0