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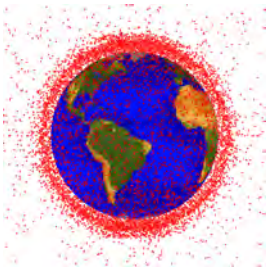

A publication of the NASA Orbital Debris Program Office

Recent Breakup of a DMSP Satellite

On 03 February 2015, at approximately 17:40 UT, a Defense Meteorological Satellite Program (DMSP) spacecraft experienced a single breakup event, resulting in the creation of a new debris cloud. This spacecraft is part of a series of satellites used to monitor meteorological, oceanographic, and solar-terrestrial physics for the United States Department of Defense. Known as USA 109 (International Designator 1995-015A, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog number 23533) and also as DMSP 5D-2/F13, this ~850 kg spacecraft was launched on 24 March 1995 in a nearly circular orbit at an altitude of about 840 km and an inclination of 98.75º.

By 12 March 2015 a total of 67 debris had been officially cataloged by the US Space Surveillance Network (SSN), but many more are being tracked that may eventually be added to the catalog, possibly pushing the total number well above 100. Figure 1 illustrates the relatively wide dispersion of the debris, extending more than 300 km above and below the pre-breakup orbit. The debris cloud is mostly symmetric in altitude, with a similar number of debris thrown into orbits with longer periods than the parent body as those with shorter periods. Similarly, about half the debris were put into orbits with inclinations higher than the parent spacecraft, and half into orbits with lower inclinations. Unfortunately, this altitude regime is particularly cluttered with debris from a large number of historical breakups. The event occurred at a high enough altitude that much of the debris from this breakup will remain in orbit for many decades.

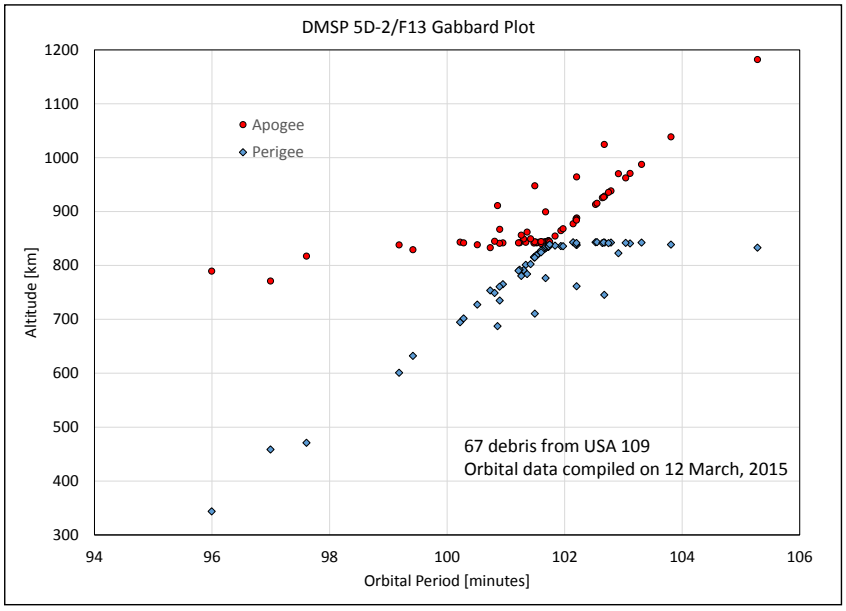

Figure 1. A Gabbard plot showing the dispersion of 67 debris from the USA 109 breakup on 03 February 2015. Approximate epoch is 12 March 2015.

Because the spacecraft was still active when the event occurred, telemetry data from the spacecraft was available to assess the cause of the breakup. While the anomaly investigation is ongoing, preliminary analysis indicates that this was an explosion of one of its Ni-Cd batteries.

Note that on 15 April 2004, a similar DMSP

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Recent Breakup

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Figure 2. An artist's conception of the DMSP 5D-2 spacecraft in orbit. Figure courtesy of the Office of the Historian, National Reconnaissance Office (http://www.nro.gov/history/csnr/programs/docs/prog-hist-02.pdf).

satellite, USA 73 (DMSP 5D-2/F11, 1991-082A, 21798) broke up due to unknown reasons (see ODQN, vol. 8, issue 4, October 2004), producing a comparable size debris cloud (84 debris currently catalogued). That spacecraft, illustrated in Fig. 2, had been decommissioned and was no longer functional at the time of breakup, so no telemetry was available to assess the cause. However, the batteries had been discharged at the time of decommissioning, so a battery explosion was ruled out. ♦

The 2015 UN COPUOS STSC Meeting

The fifty-second session of the Scientific and Technical Subcommittee (STSC) of the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) was held from 02-13 February 2015 at the UN Office in Vienna, Austria. The COPUOS was set up by the UN General Assembly in 1959 to review the scope of international cooperation in peaceful uses of outer space, to devise programs in this field to be undertaken under United Nations auspices, to encourage continued research and the dissemination of information on outer space matters, and to study legal problems arising from the exploration of outer space. The COPUOS currently consists of 77 Member States and has two standing Subcommittees – the STSC and the Legal Subcommittee. The COPUOS and its two Subcommittees meet annually to consider questions put before them by the General Assembly, reports submitted to them, and issues raised by the Member States. The COPUOS and its two Subcommittees, working on the basis of consensus, make recommendations to the General Assembly. Detailed information on the work of the Committee and the Subcommittees are contained in their annual reports (available at http://www.unoosa.org/oosa/en/Reports/gadocs/coprepidx.html).

Orbital debris-related agenda items of the 52nd STSC Session included "Space Debris" and "Long-term Sustainability of Outer Space Activities (LTS)." Several STSC Member States provided overviews of their 2014 orbital debris research activities. In addition, technical presentations were given by the European Space Agency (ESA), the Inter-Agency Space Debris Coordination Committee (IADC), the International Association for Advancement of Space Safety (IAASS), and others. All technical presentations are available at http://www.unoosa.org/oosa/en/COPUOS/stsc/2015/index.html.

In 2010 the LTS working group was established to examine and propose guidelines to ensure the safe and sustainable use of outer space for peaceful purposes. However, the LTS working group spent most of the session discussing new proposed guidelines rather than those compiled by expert groups from previous years. This activity will continue during the COPUOS meeting in June. ♦

33rd Meeting of the IADC

The annual full meeting of the Inter-Agency Space Debris Coordination Committee (IADC) was hosted by the NASA delegation in Houston, Texas, United States of America, from 30 March to 02 April 2015. The IADC is composed of representatives of the Agenzia Spaziale Italiana (ASI, Italy), the Centre National d'Etudes Spatiales (CNES, France), the China National Space Administration (CNSA, the People's Republic of China), the Canadian Space Agency (CSA), the German Aerospace Center (DLR), the European Space Agency (ESA), the Indian Space Research Organisation (ISRO), the Japan Aerospace Exploration Agency (JAXA), the Korea Aerospace Research Institute (KARI, South Korea), NASA, the Russian Federal Space Agency (Roscosmos), the State Space Agency of Ukraine (SSAU), and the UK Space Agency (UK SA). With the exception of SSAU, delegations convened at the Texas A&M Mays Business School to begin four days of presentations and discussions.

The IADC was established in 1993 to promote the multi-lateral exchange of technical information on orbital debris and to foster debris mitigation strategies and techniques in the design and operation of space vehicles.

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IADC Meeting

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Proclamation

Inter-Agency Space Debris
Coordination Committee

The **Inter-Agency Space Debris Coordination Committee (IADC)** is an international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space. National Aeronautics and Space Administration (NASA) represents the United States Government and is led by the Orbital Debris Program Office which includes representatives from the Department of Defense, Federal Aviation Administration and Federal Communications Commission.

The **IADC** is the internationally recognized technical authority on orbital debris and participates in and contributes to the United Nations orbital debris activities via the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space. The United Nations Space Debris Mitigation Guidelines endorsed by the General Assembly in 2007 were based on the **IADC** Space Debris Mitigation Guidelines.

The **IADC** will host its 33rd annual meeting in Houston March 30-April 2, 2015. The City of Houston commends the work of the **Inter-Agency Space Debris Coordination Committee** and welcomes the committee members and delegates from international space agencies to Houston.

Therefore, I, Annise D. Parker, Mayor of the City of Houston, hereby proclaim March 30-April 2, 2015, as

Inter-Agency Space Debris
Coordination Committee Week

in Houston, Texas.

In Witness Whereof, I have hereunto set my hand and have caused the Official Seal of the City of Houston to be affixed this 19th day of March, 2015.

Annise D. Parker
Mayor of the City of Houston

Figure 1. Proclamation of the week of 30 March 2015 as IADC Week in the City of Houston, Texas, by Mayor Annise Parker.

Its fundamental purposes are to exchange information on space debris research activities, to facilitate cooperative research, to manage and review progress on cooperative research, and to identify debris mitigation actions. Four permanent working groups address the measurement of orbital debris, modeling and databases, protection, and mitigation. Measurements may be collected using remote (radar, optical) or *in situ* sensors, with historical emphasis on the former. The Modeling and Databases Working Group addresses short and long-term modeling projects, as well as auxiliary or support activities such as space traffic databases, computational methods, and computational performance. The Protection Working Group's concerns are theoretical and experimental aspects of space vehicle shielding and protection from hypervelocity impact phenomena. Finally, the Mitigation Working Group encourages the discussion of all aspects of debris mitigation and relevant space policy, coordinates and formulates debris mitigation strategies, techniques, and best practices, and promulgates these through the IADC Space Debris Mitigation Guidelines and supporting documents. Coordination and overall guidance is provided by the Steering Group. Interested readers are encouraged to visit the IADC public website at www.iadc-online.org.

Figure 2. Mr. Don Kessler delivers the keynote address at the opening plenary session. Mr. Kessler, NASA Senior Scientist for Orbital Debris Research (retired), is widely regarded as the originator of orbital debris study as a distinct discipline. The general public may recognize him from the eponymous "Kessler Syndrome". Mr. Kessler has authored over 100 technical papers on meteoroids and orbital debris and continues to serve the community as a consultant for NASA and other organizations.

Features of the opening plenary session included a welcome to the delegates by the Head of the NASA Delegation, Dr. J.-C. Liou; welcoming remarks by Mr. Kirk Shireman, NASA JSC Deputy Center Director, and Dr. Eileen Stansbery, NASA JSC Chief Scientist; and the presentation of a Mayoral Proclamation declaring the week of 30 March to be IADC Week in the City of Houston (Fig. 1). Mr. Don Kessler delivered the keynote address,

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Figure 3. Assembled delegates, Local Organizing Committee, and staff of the 33rd meeting of the IADC.

IADC Meeting

continued from page 3

recounting the many successes of national and international debris measurement, modeling, and mitigation activities (Fig. 2). He challenged delegates to identify debris sources with an expanded measurements program, determine criteria for an acceptable debris environment, and establish a long-term management strategy that maintains the acceptable environment. Heads of Delegations presented 2014-2015 summaries of achievements and current activities. Following this session, delegates assembled for a group photo (Fig. 3), then dispersed into their working groups to begin deliberations, either in their working group or in joint sessions, the latter to review topics of interdisciplinary interest or concern. A closing plenary on Thursday, 02 April, identified both substantial progress on several activities and key future activities during presentations by working group chairs. ♦

PROJECT REVIEW

ORDEM 3.0 and MASTER-2009 Modeled Small Debris Population Comparison

P. KRISKO, S. FLEGEL, M. MATNEY, D. JARKEY, AND V. BRAUN

The latest versions of the orbital debris engineering models, NASA's Orbital Debris Engineering Model (ORDEM) 3.0 and the European Space Agency's (ESA's) Meteoroid and Space Debris Terrestrial Environment Reference (MASTER)-2009, have been publically released. Both models have gone through significant advancements since inception, and now represent the state-of-the-art in orbital debris knowledge of their respective agencies. The purpose of these models is to provide satellite designers/operators and debris researchers with reliable and timely estimates of the artificial debris environment in near-Earth orbit. The small debris environment within the "critical size range" of 1 mm-to-1 cm is of particular interest to both human and robotic spacecraft programs. These objects are much more numerous than larger trackable debris and are still large enough to cause significant, if not catastrophic, damage to spacecraft upon impact. They are also small enough to elude routine detection by existing radars and telescopes. Without reliable detection the modeling of these populations has always coupled theoretical origins with supporting observational data in different degrees.

This report offers the initial cooperative comparison of the two models. Previous formal and informal orbital debris comparison studies have been made. The only other publically published report includes early versions of MASTER, ORDEM, and the Roscosmos Space Debris Prediction and Analysis model (SDPA) in a 2002 study [1]. Neither the previous nor the current study attempts to review model internal populations or compare subsystems or supporting data sets (*e.g.*, propagation of fragments, A/m and ΔV distributions). The models are simply run for four test cases representing four orbital regimes:

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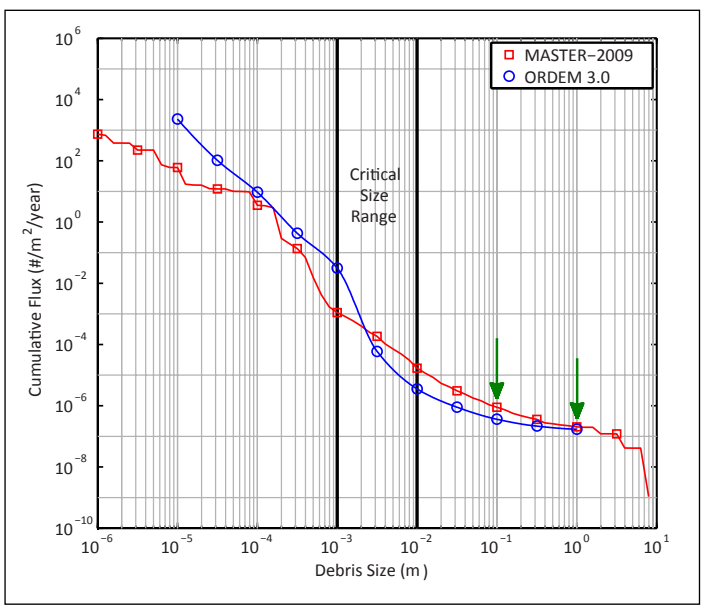

Figure 1. ORDEM 3.0 and MASTER-2009 orbital debris fluxes for the ISS in 2014. Arrows highlight the 1-m and 10-cm cumulative fluxes.

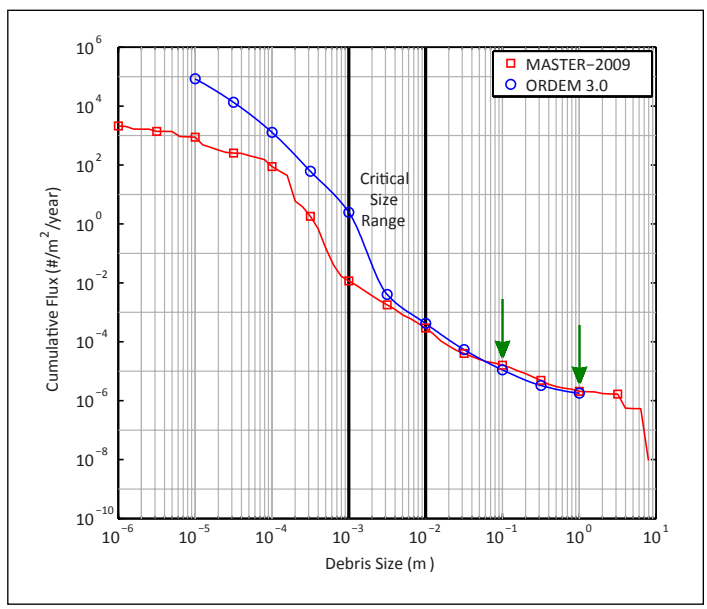

Figure 2. ORDEM 3.0 and MASTER-2009 orbital debris fluxes for the SSO in 2014. Arrows highlight the 1-m and 10-cm cumulative fluxes.

ORDEM 3.0 and MASTER-2009

continued from page 4

ISS (International Space Station), SSO (sun synchronous orbit), GTO (geosynchronous transfer orbit), and GEO (geosynchronous orbit). Debris cumulative fluxes at three debris sizes (1 m, 10 cm, and the critical size range of 1 cm-to-1 mm) are compared.

For all the non-GEO cases in Figs. 1, 2, and 3 there is a very good match between ORDEM 3.0 and MASTER-2009 fluxes at 1 meter. This would be expected given the completeness of the Space Surveillance Network (SSN) catalog at this size. The 10 cm fluxes do not match as well. The MASTER-2009 fluxes are visibly higher than those of ORDEM 3.0 in all cases. It is known that the ESA fragmentation catalog includes presumed additional events beyond those in the SSN catalog, and MASTER-2009 does include the additional events [2]. This must be thoroughly investigated in a future comparison study.

Figure 4 displays the GEO flux comparison. The ORDEM 3.0 flux is comprised of objects in GEO orbits larger than 10 cm and by any objects in GTO orbits that intersect GEO. NASA chose not to consider

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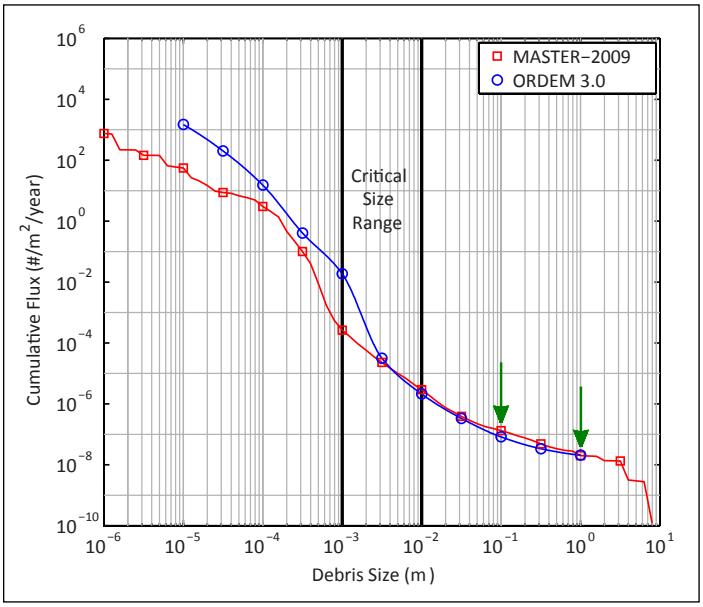

Figure 3. ORDEM 3.0 and MASTER-2009 orbital debris fluxes for the GTO in 2014. Arrows highlight the 1-m and 10-cm cumulative fluxes.

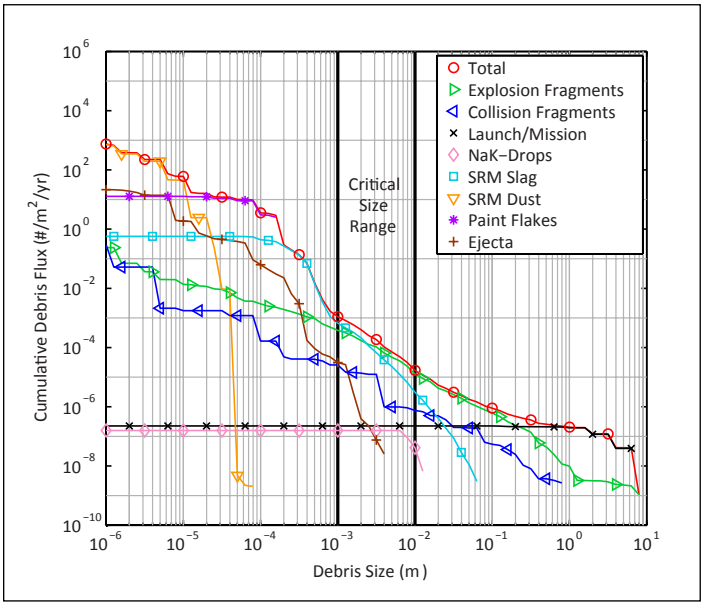

Figure 5. MASTER-2009 debris source population fluxes for the ISS in 2014.

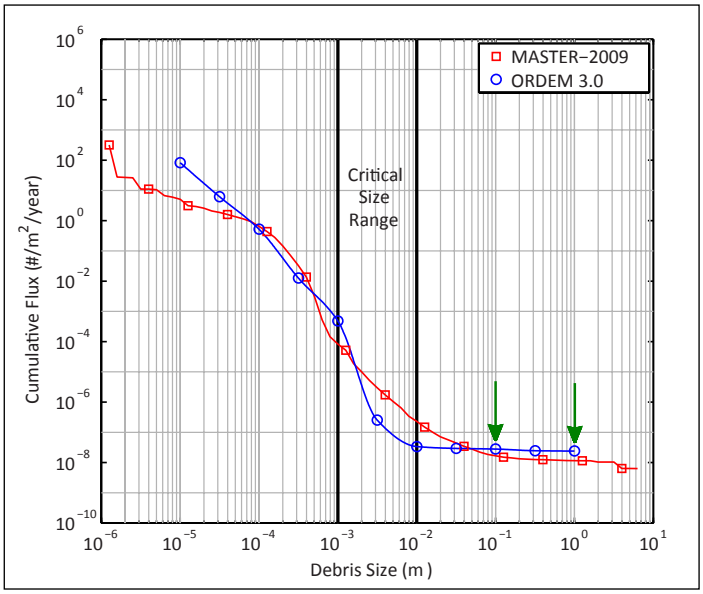

Figure 4. ORDEM 3.0 and MASTER-2009 orbital debris fluxes for the GEO in 2014. Arrows highlight the 1-m and 10-cm cumulative fluxes.

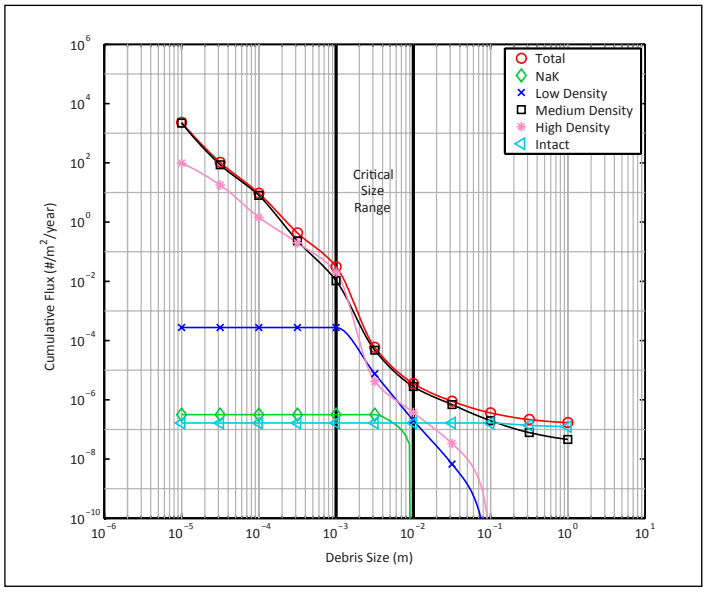

Figure 6. ORDEM 3.0 debris material density population fluxes for the ISS in 2014.

ORDEM 3.0 and MASTER-2009

continued from page 5

the smaller debris in ORDEM 3.0 GEO orbits since there is no available data on these objects. In Fig. 4 it appears likely that an addition to the ORDEM 3.0 GEO population of less than 10 cm fragments would result in a flux higher than that of MASTER-2009, the same conclusion as all other orbits.

Within the critical size range it is notable that the ORDEM 3.0 flux overtakes that of MASTER-2009 as debris size decreases in all four test cases. A view of the MASTER-2009 and ORDEM 3.0 component populations may shed light on this, but is complicated by the disparate usage of debris source populations (MASTER) versus debris material density populations (ORDEM). Figures 5 and 6 display the ISS orbit with the debris split by components labeled in each figure. We can determine rough parallels between models. For example in ORDEM 3.0, the low-, medium-, and high-density objects larger than approximately 3 mm are derived from fragmentation debris in NASA supporting models. Thus these combined material densities in ORDEM 3.0 population files can be compared directly with the larger than approximately 3 mm explosion and collision fragment source population of MASTER-2009.

The case of the solid rocket motor (SRM) slag and dust in the MASTER-2009 model is of interest. The MASTER-2009 SRM slag population forms one of the dominant sources of debris in the critical size range on all four test cases. An ESA study in 2008 showed that so called "multiple orbital event sequences" on NASA's Long Duration Exposure Facility (1984 – 1990) could be directly attributed to SRM dust trails left by SRM firings, verifying the relevance of modeling SRM dust and slag debris from these firings [3].

Slag in ORDEM 3.0 would be identified as a medium-density component. NASA acknowledges no major population that could be identified with slag, based on radar measurements and the historical reduction of SRM vehicles since the 1990s. Returned Space Shuttle window data analysis indicates that SRM aluminum oxide impacts are minor contributors. Two percent of identified impactors on the windows from 1992 to 2011 have been identified as aluminum oxide [4].

These points must be addressed in further studies and may require new datasets to reach satisfaction. With advances in modeling and data analysis and the growing importance given to debris studies, NASA and ESA collaboration to explore differences in philosophy and results between ORDEM 3.0 and MASTER-2009 will continue.

References

1. Sdunnus, H., Beltrami, P., Klinkrad, H., *et al.* "Comparison of Debris Flux Models," *Adv. Space Res*, vol. 34, issue 5, pp. 1000-1005, (2004).

2. Flegel, S., Gelhaus, J., Möckel, M., *et al.* "Maintenance of the ESA MASTER Model – Final Report," ESA Contract Number: 21705/08/D/HK, European Space Agency, June 2011.

3. Stabroth, S., Homeister M., Oswald M., *et al.* "The influence of solid rocket motor retro-burns on the space debris environment," *Adv. Space Res*, vol. 41, issue 5, pp. 1054–1062, (2008).

4. J. Hyde. private communication, 2012. ♦

Orion EFT-1 Postflight MMOD Inspection

J. HYDE, E. CHRISTIANSEN AND D. LEAR

The Orion EFT-1 mission launched from Cape Canaveral on 05 December 2014 and ended nearly 4.5 hours later with a successful recovery in the Pacific Ocean off of San Diego. As shown in Fig. 1, the first orbit had an apogee altitude of 890 km and a perigee of 200 km. The second orbit reached an apogee of 5,808 km. NASA civil servants and contractors from the Hypervelocity Impact Technology (HVIT) Group at the Johnson Space Center as well as Lockheed Martin personnel from Denver performed postflight inspections for micrometeoroid and orbital debris (MMOD) damage on the EFT-1 capsule at the Naval Base San Diego Mole Pier and the Launch Abort System Facility at the Kennedy Space Center. The Orion capsule was recovered in good shape, but the forward bay cover (jettisoned during the main parachute deployment) sank before it could be recovered. Capsule areas that were examined during the inspection campaign include the back shell thermal protection system tiles, back shell thermal barriers, reaction control system thruster nozzles, base heat shield acreage,

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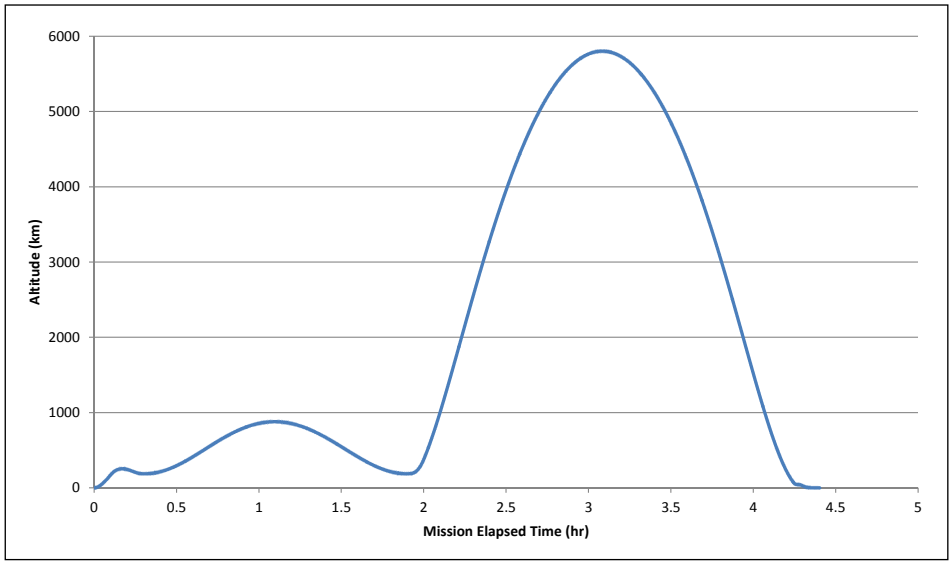

Figure 1. EFT-1 altitude versus mission time.

Orion EFT-1 Inspection

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docking hatch thermal protection system blankets, docking hatch window, and crew module windows.

In general, the postflight MMOD inspection process can be divided into four tasks:

- **Survey:** initial screening for defects and anomalies
- **Characterization:** examination for distinctive hypervelocity impact (HVI) features
- **Documentation:** location and feature sizes of HVI defects are measured and recorded
- **Analysis:** detailed investigation to discern details of impact source.

The first two activities are performed in the field while the documentation task can include both field and lab work. We have completed the field work and are now involved in the lab work. Specifically, we are now conducting non-destructive evaluation (NDE) of the suspected MMOD impact features using X-ray computed tomography (CT) and optical

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Table 1. EFT-1 Postflight MMOD Inspection Preliminary Findings, TPS

Surface Type	ROI #	Capsule Region	Feature Size (mm) Length	Width	Depth	Sample	Preliminary Disposition
TPS	4	Panel A, Tile 33	0.51	0.50	0.50	intact extraction of tile	possible MMOD
TPS	7	Panel C, Tile 73	1.29	1.10	0.05	intact extraction of tile	possible MMOD
TPS	20	Panel H, Tile 144	0.63	0.56	0.54	intact extraction of tile	possible MMOD
TPS	23	Panel I, Tile 45	1.18	1.15	0.60	TBD	possible MMOD
TPS	24	Panel F, Tile 45	1.06	1.02	1.02	intact extraction of tile	possible MMOD
TPS	25	Panel A, Tile 8	1.88	1.27	0.70	intact extraction of tile	possible MMOD

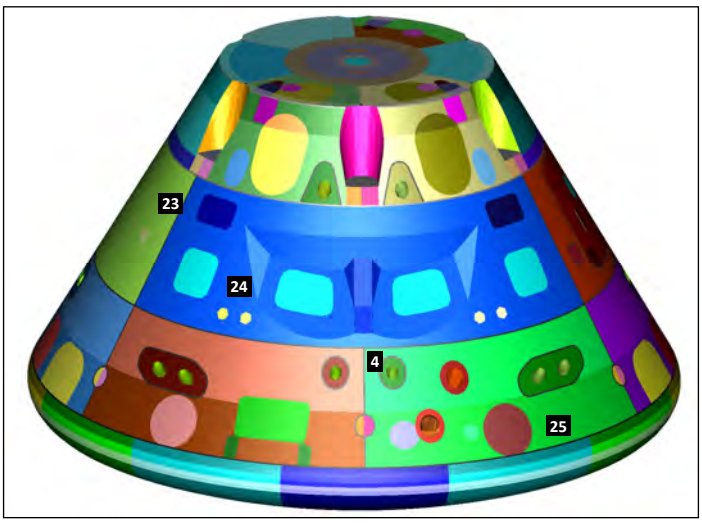

Figure 2. EFT-1 postflight MMOD inspection preliminary findings, backshell TPS: 0° view.

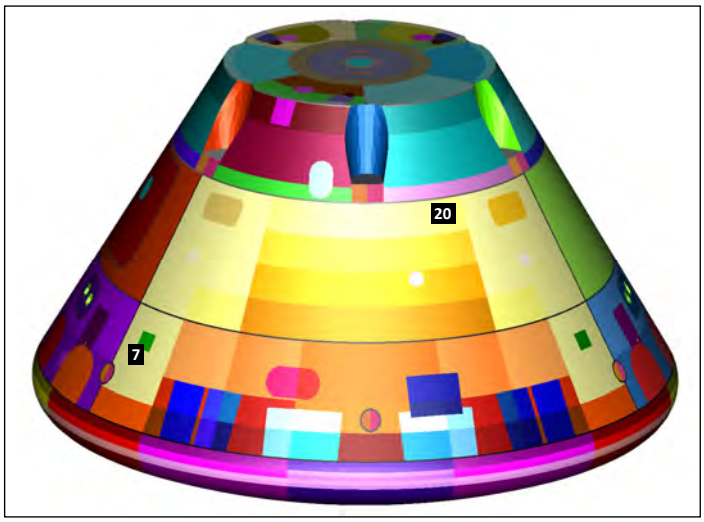

Figure 3. EFT-1 postflight MMOD inspection preliminary findings, backshell TPS: 180° view.

Figure 4. Field imagery of ROI #20, feature size = 0.63 x 0.56 mm, depth = 0.54 mm.

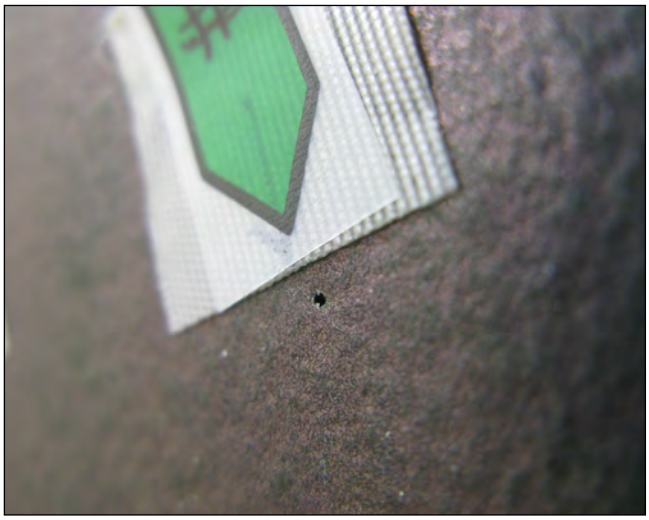

Figure 5. Field imagery of typical region of interest (ROI #20).

Orion EFT-1 Inspection

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microscopy. After the NDE work, a scanning electron microscope with energy-dispersive X-ray spectroscopy (SEM/EDX) will be used to characterize the elemental composition of HVI impactor residue.

Initial surveys and characterizations produced 25 regions of interest (ROI) on backshell thermal protection system tiles. An internal imagery review and additional inspections reduced the ROI list down to six features that were designated as "possible MMOD." Table 1 provides details of the six potential impact sites in the TPS tiles. Figures 2 and 3 provide general locations of the six regions of interest on the capsule TPS. Figures 4 and 5 show typical imagery acquired during inspection work in the field. Five of the six tiles containing the potential MMOD damage were removed and sent to the HVIT group at JSC for additional analysis with higher magnification microscopes and 2D/3D surface profilers. A typical microscope image and 2D crater profile from the lab can be seen in Fig. 6.

Four crew module windows and the hatch window were also examined for MMOD damage features. A total of 42 small window features were found; 27 on the crew module windows and 15 on the hatch window. It is very possible these small features were due to a non-MMOD source, but the investigation into the cause of these damages is on-going. Figure 7 provides the total number of observations for each window. The damage features in the windows (see Fig. 8) were all fairly consistent in appearance and ranged from 0.1 mm diameter to 0.5 mm diameter.

An as-flown analysis was performed by Lockheed Martin against the final trajectory using the Bumper 3 code and the ORDEM 3 orbital debris environment. Figure 9 shows the observed TPS tile damage (in this case depth was used) with the results of the Bumper

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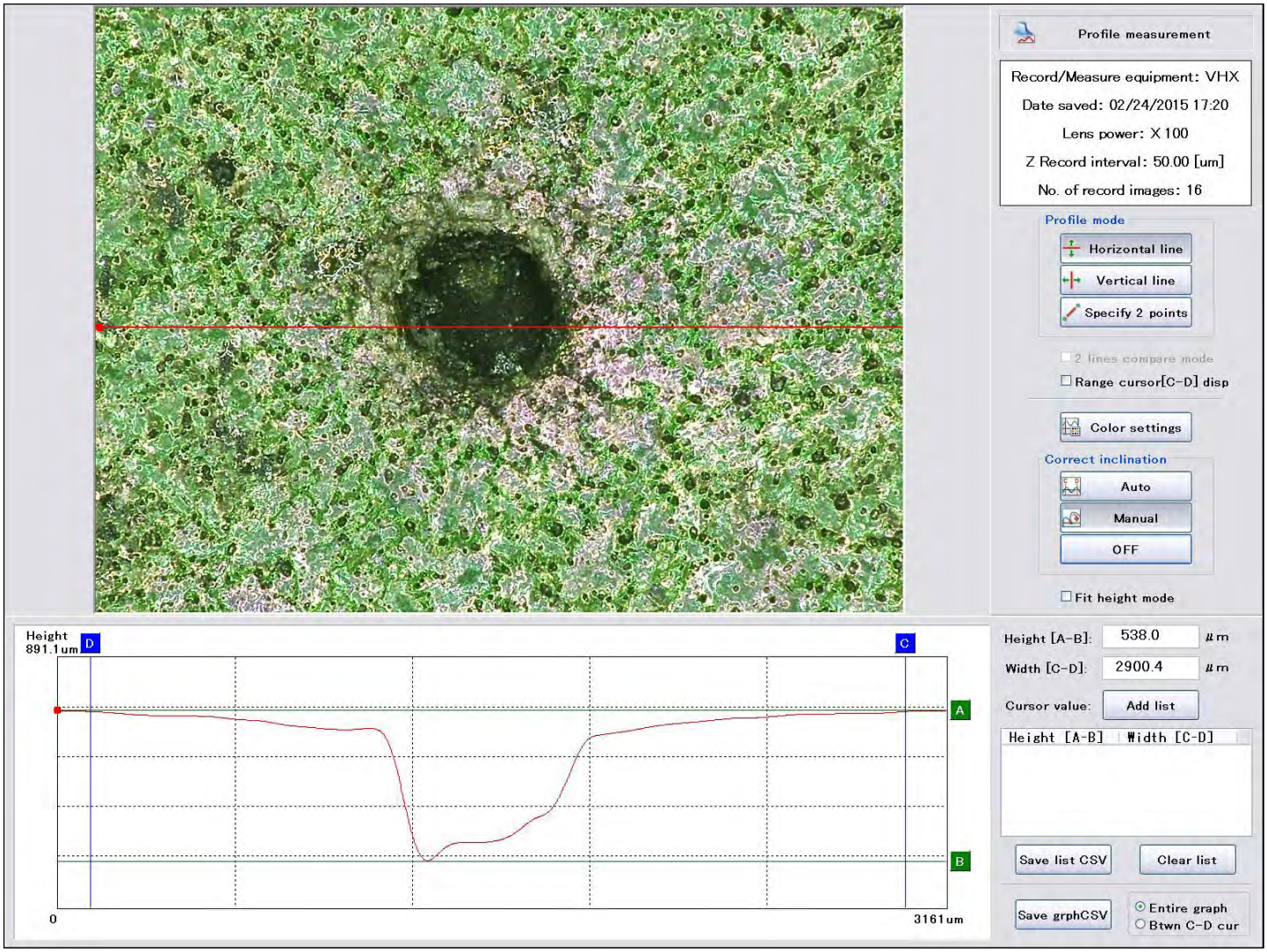

Figure 6. Laboratory measurement of region of interest #20.

Orion EFT-1 Inspection

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code predictions for ORDEM 3 (including MEM-R2). Preliminary results indicate that more damage was observed than predicted by the as-flown assessment. A similar assessment was performed for window damage based on internal fracture diameter and ORDEM 3 predicted 0.2 features of 0.3 mm and greater diameter. Assessment work is still underway. ♦

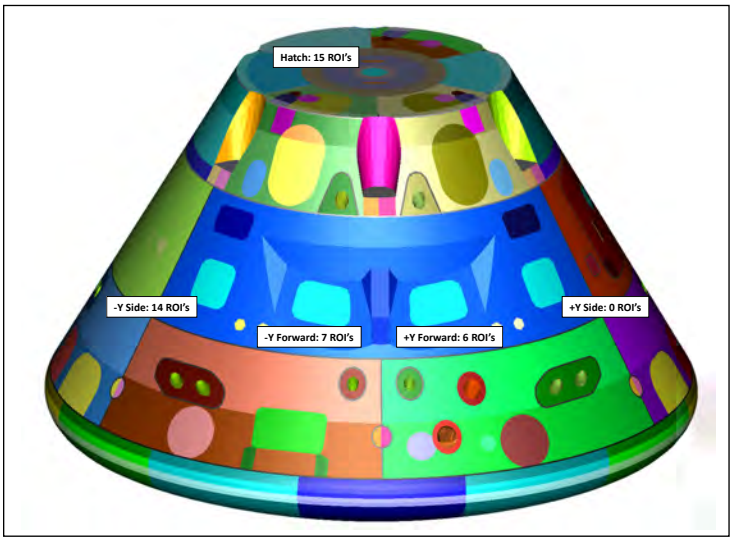


Figure 7. EFT-1 postflight MMOD inspection results, crew module and hatch windows.

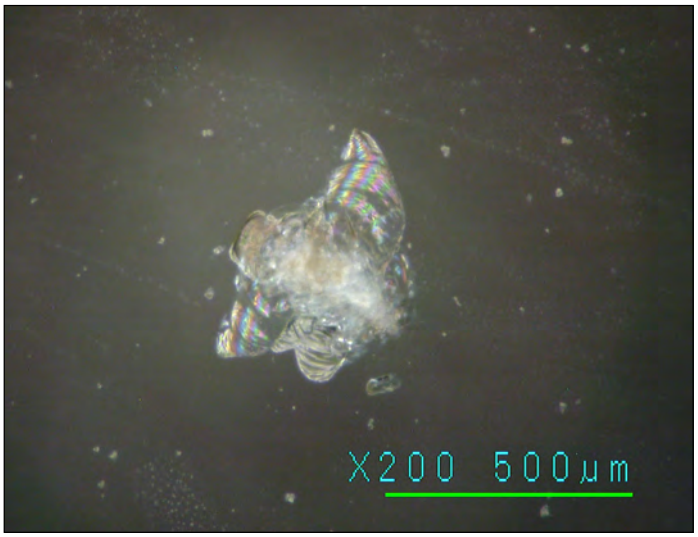


Figure 8. Typical crew module window impact of ROI #19 (+Y forward). Internal fracture dimensions = 0.51 x 0.41 mm diameter, crater dimensions = 0.36 x 0.18 mm diameter, depth = 0.03 mm.

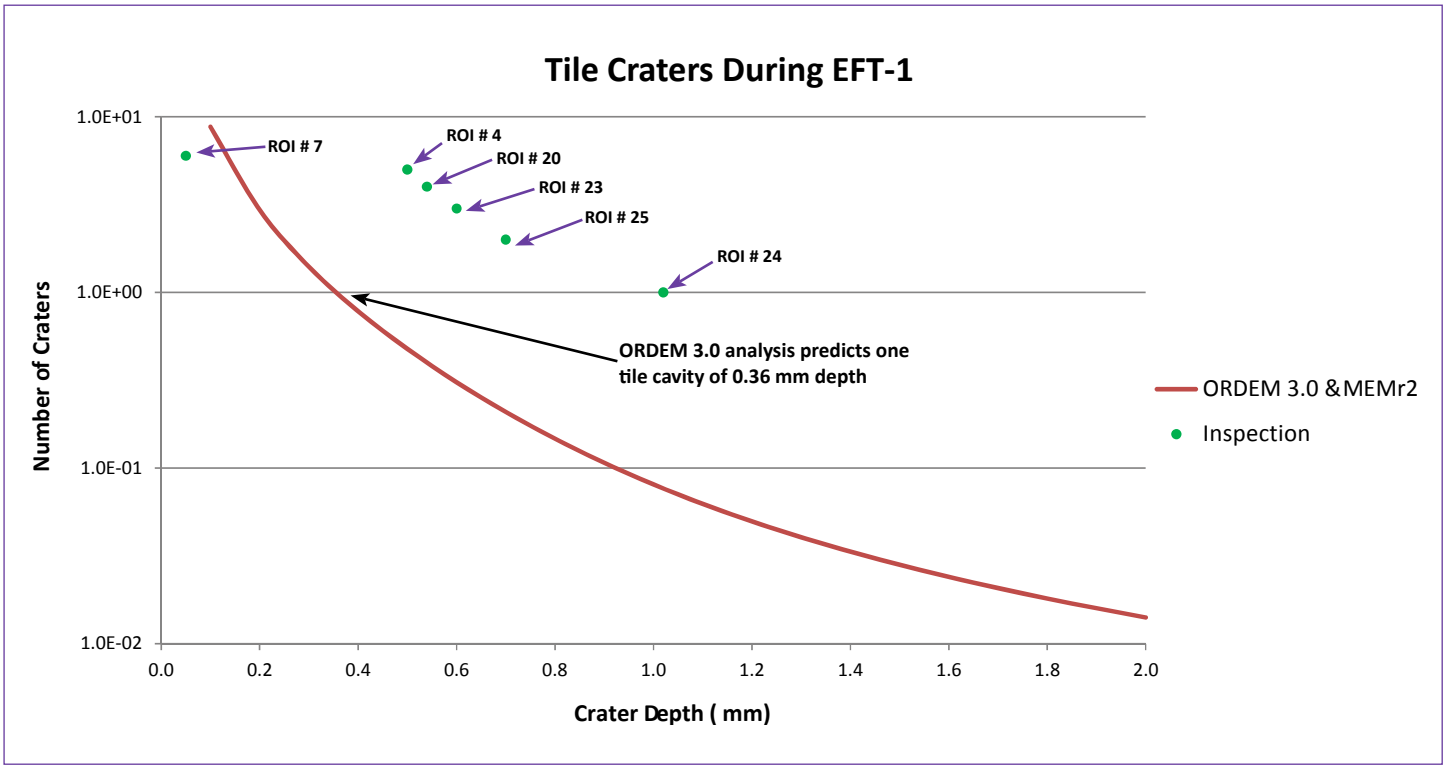


Figure 9. As flown prediction for tile crater depth compared to observations.

CONFERENCE REPORT

The Cube Quest Challenge Summit, 07-08 January 2015, NASA Ames Research Center, Mountain View, California

The Cube Quest Summit was held 07-08 January at NASA Ames Research Center (ARC) in Mountain View, California. The ARC is the administrator of the Cube Quest Challenge, a NASA Centennial Challenge Program competition that offers a total of $5 million to teams that meet the challenge objectives to design, build, and deliver flight-qualified, small satellites capable of advanced operations near and beyond the moon.

The meeting provided rules for interested individuals to follow and a networking opportunity to meet like-minded individuals and form teams.

Presentations included information on the deployment system to be used, on milestones required to qualify for awards, on mission operations, on safety and mission assurance, on orbital debris mitigation requirements, and on planetary protection requirements.

The Orbital Debris Mitigation Policy presentation provided a walkthrough of NASA Standard 8719.14 (NS 8719.14) and discussed how each section of the policy applied to lunar orbiting vehicles. For these vehicles, NS 8719.14 recommends that missions limit operational debris. Limiting accidental and intentional explosions is also required for lunar orbiting missions, as well as risk requirements for collisions with small and large objects. For missions going far beyond lunar orbit there are currently no requirements to meet.

Cube Quest teams can compete for a secondary payload spot on the first mission of NASA's Orion spacecraft. Further details can be found on the NASA Cubequest Challenge website at http://www.nasa.gov/cubequest. The Summit presentations are available online at http://www.nasa.gov/cubequestsummit. ♦

UPCOMING MEETINGS

04-10 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/.

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.

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.

Errata for ODQN "International Space Missions"

The ODQN 19-1 listed two cataloged payloads as "EN ROUTE TO GEO." When an object's orbital elements and other sources indicate it is in a transitional phase, the ODQN International Space Missions table shows "EN ROUTE TO…" rather than the temporary orbit. At the time of publication, International Designators 2014-089A and 2014-090A (the communications satellite ASTRA 2G and the weather satellite FENGYUN 2G, respectively) were in GEO transfer orbits with low perigees. The ASTRA 2G is now in an operational orbit with perigee altitude of 35,776 km, apogee altitude of 35,794 km, and inclination of 0.1 degree. The FENGYUN 2G has reached its final orbit of 35,771 km by 35,808 km by 2.1 degrees. Upon reaching GEO, 2014-090A released an additional debris object: a solid-fueled apogee kick motor which has been given the International Designator 2014-090C. ♦

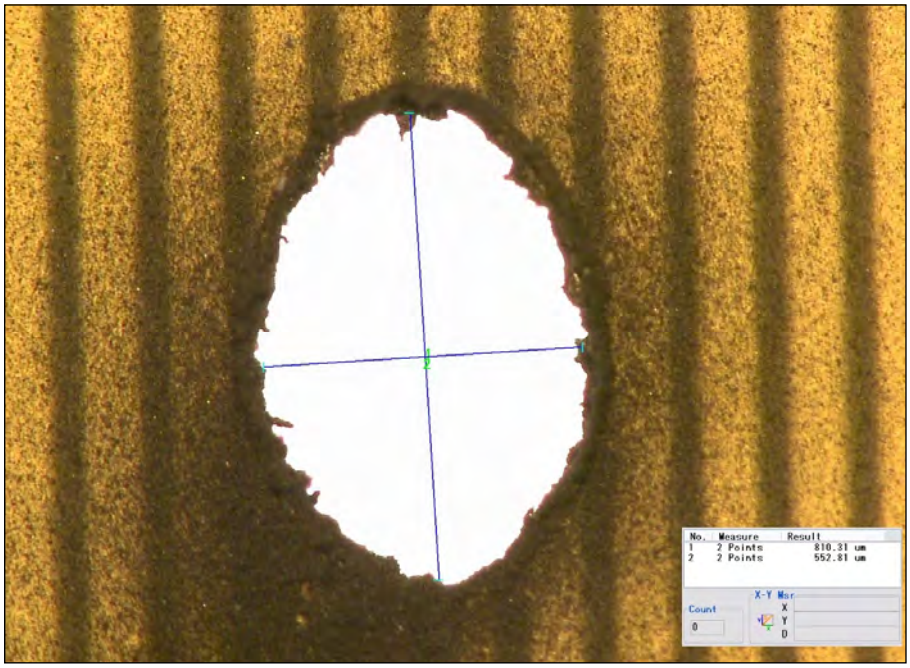
Space Debris Sensor (SDS) testing in progress at NASA White Sands Test Facility

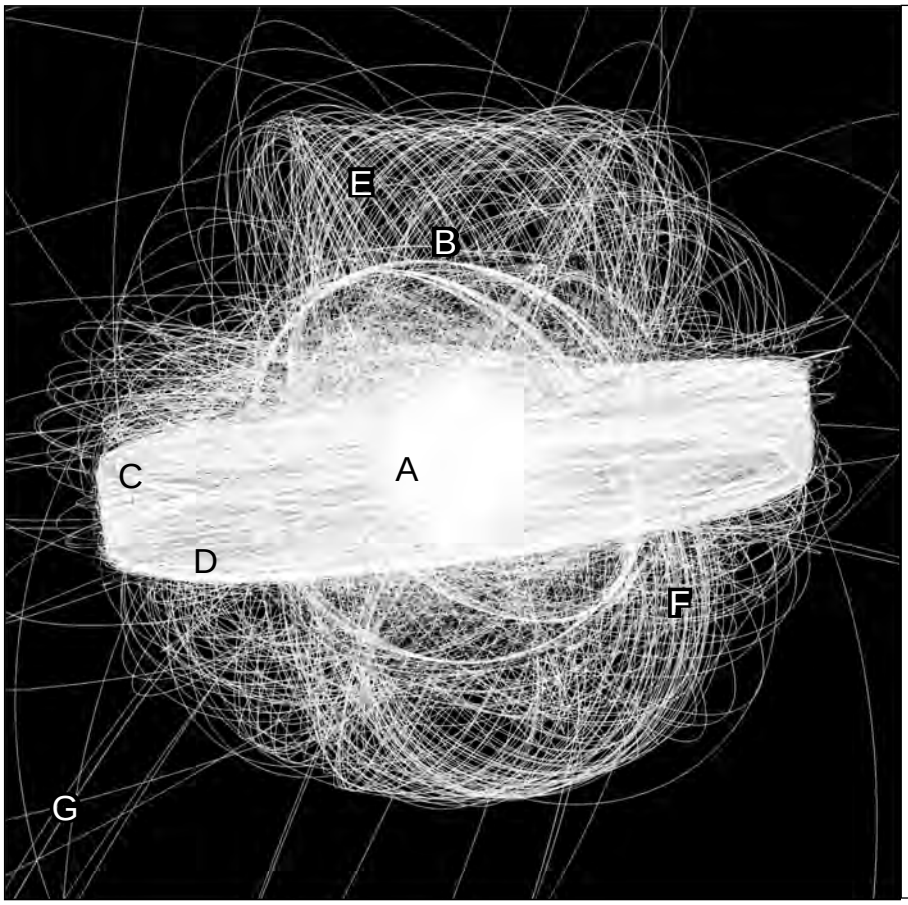
ODQN Issue 19-1, in "DRAGONS to Fly on the ISS," described an innovative sensor technology to be developed for an ISS payload, since renamed the Space Debris Sensor (SDS).

As described in that article, the outer layer of the sensor is a 1 mil-thick film of Kapton bearing a grid of resistive material. Severed grid lines provide an estimate of impactor size by comparing before and after measurements of the grid's total electrical resistance.

Testing being conducted at the NASA White Sands Test Facility (WSTF) confirms this technique and is being used to determine damage-to-size criteria for SDS data reduction and analysis. An example is shown in this figure; here, a 500 μm aluminum spherical projectile struck the grid at an angle of 45°.

In this figure, dark conducting grid lines have been severed by the projectile, and digital microscopic analysis estimates the size of the elliptical penetration as approximately 553 x 810 μm.





Many readers are familiar with portrayals of the Earth orbital population using dots to represent the position of a cataloged object at one common instant in time.

This graphic expands that concept to display the entire orbit trace of a given object. Visible are:

(A) the low Earth orbit (LEO) "halo",

(B) the circular, 12-hour period orbits in middle Earth orbit (MEO),

(C) the equatorial ring of active spacecraft in geosynchronous orbit (GEO),

(D) the tilted "stable plane" of inactive objects in GEO,

(E) the highly elliptical Molniya-type orbits with perigees deep in the southern hemisphere,

(F) the GEO transfer orbits (GTO), and

(G) the high Earth orbit (HEO) space objects in circular and elliptical orbits.

This environmental snapshot was produced using the 01 June 2011 catalog of two-line element sets.

SATELLITE BOX SCORE

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

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	177	3539	3716
CIS	1462	4850	6312
ESA	51	45	96
FRANCE	59	445	504
INDIA	58	109	167
JAPAN	137	73	210
USA	1300	3842	5142
OTHER	663	116	779
TOTAL	3907	13019	16926

DAS 2.0 NOTICE

Attention DAS 2.0 Users: an updated solar flux table is available for use with DAS 2.0. Please go to the Orbital Debris Website (http://www.orbitaldebris.jsc.nasa.gov/mitigate/das.html) to download the updated table and subscribe for email alerts of future updates.

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INTERNATIONAL SPACE MISSIONS
1 January 2015 – 31 March 2015

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2015-001A	DRAGON CRS-5	USA	399	407	51.6	1	2
2015-002A	MUOS 3	USA	35766	35806	5.0	1	0
2015-003A	SMAP	USA	681	683	98.1	0	0
2015-003B	FIREBIRD 3	USA	436	662	99.1		
2015-003C	FIREBIRD 4	USA	436	662	99.1		
2015-003D	GRIFEX	USA	437	663	99.1		
2015-003E	EXOCUBE	USA	437	665	99.1		
2015-004A	IGS	JAPAN	512	514	97.5	1	1
2015-005A	INMARSAT 5 F-2	INMARSAT	35621	35960	0.1	1	1
2015-006A	FAJR	IRAN	223	470	55.5	1	0
1998-067FM	AESP 14	BRAZIL	381	385	51.6	0	0
2015-007A	DSCOVR	USA	EARTH-SUN L1			0	0
2015-008A	PROGRESS-M 26M	RUSSIA	396	405	51.6	1	0
2015-009A	COSMOS 2503	RUSSIA	549	564	97.6	1	0
1998-067FN	FLOCK 1B 27	USA	396	402	51.6	0	0
1998-067FP	FLOCK 1B 28	USA	395	402	51.6		
1998-067FQ	FLOCK 1B 21	USA	396	401	51.6		
1998-067FR	FLOCK 1B 22	USA	395	403	51.6		
1998-067FS	FLOCK 1B 10	USA	393	405	51.6		
1998-067FT	FLOCK 1B 9	USA	394	405	51.6		
1998-067FU	FLOCK 1D 1	USA	394	405	51.6		
1998-067FV	FLOCK 1D 2	USA	394	406	51.6		
1998-067FW	FLOCK 1B 5	USA	395	406	51.6		
1998-067FX	FLOCK 1B 6	USA	395	407	51.6		
1998-067FY	TECHEDSAT 4	USA	243	255	51.6		
1998-067FZ	GEARRS-1	USA	386	396	51.6		
1998-067GA	MICROMAS	USA	381	391	51.6		
1998-067GB	LAMBDASAT	USA	369	379	51.6		
1998-067GC	FLOCK 1B 11	USA	385	392	51.6		
1998-067GD	FLOCK 1B 12	USA	389	396	51.6		
2015-010A	ABS 3A	CHINA	EN ROUTE TO GEO			1	0
2015-010B	EUTE 115 WEST B (SATMEX7)	EUTELSAT	EN ROUTE TO GEO				
2015-011A	MMS 1	USA	1084	70124	28.9	1	0
2015-011B	MMS 2	USA	1327	70120	28.9		
2015-011C	MMS 3	USA	1301	69928	28.9		
2015-011D	MMS 4	USA	1030	70183	28.9		
2015-012A	EXPRESS AM7	RUSSIA	EN ROUTE TO GEO			1	1
2015-013A	NAVSTAR 73 (USA 260)	USA	20318	20469	55.0	1	0
2015-014A	KOMPSAT 3A	SOUTH KOREA	522	541	97.5	1	1
2015-015A	IGS OPTICAL 5	JAPAN	473	476	97.4	1	1
2015-016A	SOYUZ-TMA 16M	RUSSIA	396	405	51.6	1	0
2015-017A	GALILEO 7 (263)	ESA	23566	23609	55.1	1	0
2015-017B	GALILEO 8 (264)	ESA	23565	23570	55.1		
2015-018A	IRNSS 1D	INDIA	EN ROUTE TO GEO			1	0
2015-019A	BEIDOU I1-S	CHINA	35797	36781	55.0	1	0
2015-020A	OBJECT A	RUSSIA	1497	1509	82.5		
2015-020B	OBJECT B	RUSSIA	1496	1507	82.5		
2015-020C	OBJECT C	RUSSIA	1495	1506	82.5		
2015-020D	OBJECT D	RUSSIA	1171	1505	82.5		
2015-020E	OBJECT E	RUSSIA	1173	1506	82.5		