National Aeronautics and Space Administration

Orbital Debris Quarterly News

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Inside...

A publication of the NASA Orbital Debris Program Office

Dr. John W. Lyver, IV, Retires as NASA Program Executive for Orbital Debris

Dr. John W. Lyver, IV, retired from NASA's Office of Safety and Mission Assurance (OSMA) at the end of June this year. John had served as NASA's Program Executive for the Micrometeoroid and Orbital Debris (MMOD) program since 2005. In this role, he coordinated MMOD requirements and the project elements, budget, and interfaces with NASA spaceflight programs. He also served as NASA's Manager for Nuclear Flight Safety Assurance and managed NASA's documents and standards developed by the NASA Safety and Mission Assurance Technical Authority.

John began his career with the U.S. Navy, graduating from the U.S. Naval Academy with an Engineering-Physics degree in 1978. Always stretching his boundaries, he recently received his Ph.D. in Computational Science and Informatics from George Mason University.

Working at NASA was a dream of John's from the time he watched John Glenn's Mercury flight orbit the Earth. He joined NASA after retiring from the Navy and worked on the Space Station Freedom Project in Reston, VA.

Dr. John Lyver (right) is presented with a signed picture by Wilson Harkins (left) and the OSMA staff in recognition of his years of service with NASA and the MMOD program.

In his spare time, which he now has more of, John is a very active Boy Scout Leader and holds the Silver Beaver Award, the Vigil Honor, and multiple Woodbadge beads.

John remains a very strong advocate for the MMOD program and his contributions will be sorely missed. ♦

New Version of DAS Now Available

A minor revision of the Debris Assessment Software (DAS) 2.0 has been released. DAS 2.0.2 includes some code changes as well as an updated software installer and User's Guide. The features of DAS have not changed with this release.

The two changes most apparent to the user will be the new software installer and the corrected materials list. The new installer (NSIS) is compatible with current Microsoft Windows operating systems, both 32- and 64-bit versions. The materials list, used in the assessment of reentry casualty risk (Requirement 4.7-1), has been revised to improve nomenclatures. Note that old (DAS 2.0.1) projects that use any of the 10 corrected materials will need to be updated with the new material names.

Other important changes include improved collision risk assessments.

DAS 2.0.2 also includes several minor changes. The orbit propagation time-step, previously set to

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New Version of DAS

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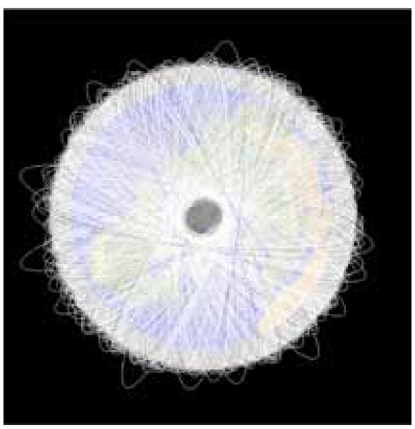
different values in different computational modules, has been set to a single value of 2 days. The unused input "Retraction Year" has been removed from the GUI for assessment of Collision Hazards of Space Tethers (Requirement 4.8-1). The software User's Guide has been updated to include the new software installation and removal procedures, and to clearly state the assumptions behind the assessment of tethers. Lastly, the solar flux data file is updated to the version of 4 April 2012. A list of the changes is in the "Release Notes" file, which is installed with DAS and is available on the DAS web page: http://orbitaldebris.jsc.nasa.gov/mitigate/das.html.

DAS users should discontinue using version 2.0.1 and install the new version 2.0.2. By default, the new version will install over the previous version, or users may remove the previous version using the Windows Control Panel "Add/Remove Software" feature. ♦

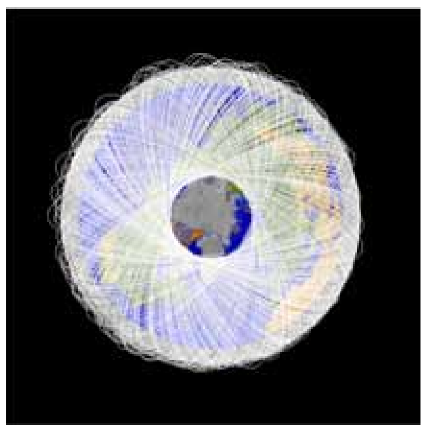
Status of Three Major Debris Clouds

The U.S. Space Surveillance Network continues to catalog debris from the two most prolific events in Earth orbit: the intentional destruction of the Chinese Fengyun-1C spacecraft in January 2007 and the accidental collision of the Russian Cosmos 2251 and the U.S. Iridium 33 spacecraft in February 2009. By 1 July a total of more than 5500 debris had been officially cataloged with these breakups, 90% of which were still in orbit about the Earth. These debris represent 36% of all objects residing in or passing through low Earth orbit, *i.e.*, less than 2000 km altitude.

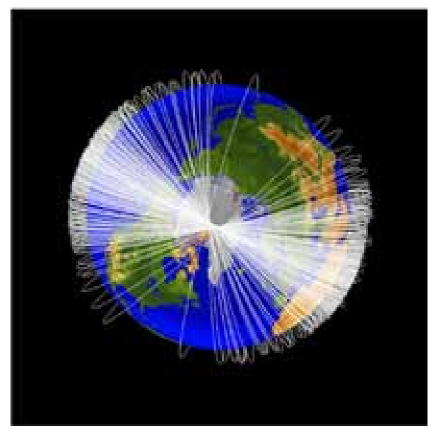
The illustrations below clearly indicate that the debris from Fengyun-1C and Cosmos 2251 now completely encircle the planet. Since Iridium 33 was in a nearly polar inclination (86.4 degrees), the orbital planes of its debris are taking longer to diverge as a result of lower differential precession rates. ♦



Fengyun-1C debris orbits



Cosmos 2251 debris orbits



Iridium 33 debris orbits

Development of DRAGONS – An MMOD Impact Detection Sensor System

Due to the high impact speed in the low Earth orbit (LEO) region, with an average of 10 km/sec, orbital debris (OD) larger than about 200 µm are a safety concern for human space activities and robotic missions. Similar risks also come from small micrometeoroids. To define the OD environment to cover the entire spectrum of the population, different observational approaches are needed. In-situ measurements are the best option to collect data for particles a few millimeters and smaller. The NASA Orbital Debris Program Office has been supporting the development of a new particle impact detection system, Debris Resistive/Acoustic Grid Orbital Navy Sensor (DRAGONS), since 2007. The effort is led by the U.S. Naval Academy (USNA), with additional collaboration from the U.S. Naval Research Laboratory (NRL), the University of Kent at Canterbury in Great Britain, and Virginia Tech (VT).

DRAGONS combines two different impact detection technologies – resistive grid sensors (RGS) and polyvinylidene fluoride (PVDF) acoustic sensors, to maximize information that can be extracted from particle impacts. A basic RGS unit has dimensions of 25 cm by 25 cm. The surface consists of 75 µm-wide resistive lines, lying in parallel and separated by 75 µm gaps, on a 25 µm-thick Kapton thin film. Four PVDF sensors are attached to the backside of the thin film. A second Kapton layer, with another four PVDF sensors attached to the backside, is placed 10 cm below the first layer. When a particle a few hundred micrometers or

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DRAGONS

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larger strikes the top layer, it will penetrate the thin film and sever some resistive lines. By measuring the resistance increase of the layer, the number of destroyed resistive lines and an estimate of the impacting particle's size can be determined. The PVDF acoustic sensors on the top film provide the impact timing and location information using the measured acoustic signal arrival times at the four sensor locations. After the particle hits the bottom film, the impact timing and impact location information on the film are also provided by the acoustic sensors. The combination of acoustic data from the two layers can then be used to estimate the impact speed and impact angle.

The short-term goal of DRAGONS is to advance the Technology Readiness Level to 9 and to demonstrate the system capabilities of detecting and characterizing sub-millimeter micrometeoroid and orbital debris (MMOD) impacts on the International Space Station. The long-term goal is to deploy a large detection area (>1 m^2) DRAGONS to 700-1000 km altitude to collect sufficient data for better environment definition of orbital debris in the 0.5-to-1-mm size regime. The DRAGONS project reached a major milestone when the Preliminary Design Review (PDR) was held at the USNA on 13 June. The PDR included a project status overview by the Principal Investigator Professor A. Sadilek (USNA), an electronics system review by Professor C. Anderson (USNA), a system interface status by Professor R. Bruninga (USNA), an acoustic system review by Dr. R. Corsaro (NRL), and an RGS system review and hypervelocity impact testing at Kent by Dr. F. Giovane (VT). In addition, Dr. P. Ballard from the DoD's Space Test Program (STP) also described a potential STP flight opportunity to deploy and demonstrate a 0.5 m^2 DRAGONS on the International Space Station in 2014. ♦

15th Annual NASA/DoD Orbital Debris Working Group Meeting

The 15th meeting of the NASA/DoD Orbital Debris Working Group (ODWG) was held on 17-18 April 2012. Although NASA's Orbital Debris Program Office (ODPO) was the official host of the meeting, most participation was accomplished virtually via telecon. The ODWG was formed based on recommendations by interagency panels, who reviewed U.S. Government orbital debris (OD) activities in the late 1980s and 1990s. The 1 1/2-day meeting reviewed activities and research in OD with a common interest to both NASA and DoD and included 1/2 day on Active Debris Removal activities.

After short introductory remarks, Mr. Nicholas Johnson gave his annual summary of OD activities at the Inter-Agency Space Debris Coordination Committee (IADC) and at the United Nations (UN) for the past year. The IADC activities included two reentry exercises conducted in 2011 – the NASA Upper Atmosphere Research Satellite (UARS) spacecraft in September and the DLR Roentgen Satellite in October. The UN activities included progress by the Long-Term Sustainability of Space Activities Working Group.

Dr. Mark Matney reported on the status of NASA's OD Engineering Model, ORDEM 3.0, which should be released in the fall of 2012.

Mr. Gene Stansbery reported on the history and status of the Meter-Class Autonomous Telescope (MCAT) project, which is a collaboration between NASA and the Air Force Research Laboratory (AFRL) detachment located on Maui. Facility delays continue to slow the deployment of MCAT.

Dr. J.-C. Liou completed the NASA presentations with three reports including status of the Debris Resistive/Acoustic Grid Orbital Navy Sensor (DRAGONS) collaboration with the U.S. Naval Academy, the Mid-size Satellite Impact Test collaboration with the Air Force's Space and Missile Systems Center, and a brief preview of the second day's activities on Active Debris Removal (ADR).

The DoD made two presentations on the new Space Surveillance Telescope (SST), a new large aperture, wide field-of-view telescope currently undergoing testing. The first presentation, from Mr. Robert Hardwick, provided the status and the second, from Mr. Alan Lovell, discussed some aspects of the data analysis. NASA has great interest in sharing orbital debris data from the SST. The group also discussed the ultimate location of the SST and its impact on the location of MCAT.

The DoD continued with its annual report on the Space Surveillance Network (SSN) given by Mr. Jeff Wiseheart. The briefing included the status of the Moron optical site, which also may influence plans for MCAT.

Mr. Tim Payne briefed on efforts to improve satellite trajectory predictions and on efforts to reduce the number of cataloged objects that have been "lost," or not recently tracked.

Mr. Gary Wilson presented the status of the future Air Force Space Fence program and its siting options. The Space Fence should be able to detect OD as small as 2-cm characteristic length at human spaceflight altitudes.

Mr. Tim Payne made two additional presentations; one on the status of a Windows compatible version of SATRAK, and the second on recommendations for a new satellite catalog for the Joint Space Operations Center – the Extrapolation SGP4, or eGP.

Similar to the meeting format in 2011, the agenda on the second day was dedicated to ADR activities within the NASA and DoD communities. The objectives of the meeting were information sharing and technical interchange in preparation for potential future collaboration in ADR research and technology development.

Dr. J.-C. Liou first introduced the agenda, and then gave an overview of the various ADR activities conducted by the ODPO in the last 12 months. The highlights included a special environment remediation study and an effort to collect light curve data to characterize the tumble motion of potential ADR targets.

Mr. Tony Griffith presented an overview and concept design of the Active Debris Removal Vehicle (ADRV) mission. The effort was funded by the JSC Engineering Directorate.

Dr. Les Johnson from the NASA Marshall Space Flight Center (MSFC) provided an overview of the electrodynamic tether (EDT) propulsion technology. He summarized the previous EDT demonstration missions and the current state-of-the-art of the technology. His presentation also included an assessment of the advantages and challenges of using EDT for

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NASA/DoD OD WG

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future ADR missions.

Professor Richard Fork from the University of Alabama Huntsville, in collaboration with Mary Hovater and Jan Rogers from the NASA MSFC, described the principles of using laser systems for the removal of small orbital debris.

The three DoD presentations were given by members of the AFRL from the Kirtland Air Force Base. Dr. Alan Lovell gave a presentation on behalf of Dr. Moriba Jah. His talk focused on tracking and characterization of debris objects for orbital safety. He outlined an integrated approach for data fusion to improve information that can be extracted from observations.

Dr. Frederick Leve described a concept for passive magnetic detumbling of large/massive ADR targets with high tumble rates and proposed a potential collaboration between the AFRL and NASA JSC's Guidance, Navigation, and Control and Structure groups to mature the technology.

The last presentation of the day was given by Mr. Ted Marrujo. He described the concept of a large-area deorbit module. It has potential applications for postmission disposal of future satellites, as well as for active debris removal. ♦

The First NASA Orbital Debris Workshop

Thirty years ago NASA hosted the first U.S. national workshop on orbital debris at the Lyndon B. Johnson Space Center (JSC) in Houston, Texas. This meeting was a major undertaking by a small group of dedicated specialists at JSC, who had been tasked by NASA Headquarters just a few years earlier to research the extent and implications of the population of debris in Earth orbit.

Held during 27-29 July 1982, the workshop was attended by 90 representatives of NASA, the Department of Defense, other U.S. government organizations, the aerospace industry, and academia. Thirty-five papers were divided into special sessions for small (<1 mm) particle environment definition, large (> 1 mm) particle environment definition, spacecraft hazard and shielding requirements, space object management, and policy considerations. These papers, with the exception of two that were classified, were compiled and published as NASA Conference Publication 2360, *Orbital Debris*.

The specific topics of many of the papers are as valid today as they were in 1982. John Gabbard discussed the history and consequences of satellite breakups, and Don Kessler laid the foundation for NASA's future engineering environment models. Val Chobotov highlighted the risks of satellite collisions in both low and high Earth orbits, and Robert Reynolds, *et al.,* outlined a plan for an evolutionary model of the satellite population, which led to the development of NASA's EVOLVE model. Several authors tackled the challenges and opportunities of collecting additional data on the existing debris environment, from both terrestrial and *in situ* sensors. The space vehicle disposal and retrieval subjects were also covered, as were the policies that would be necessary to curtail the growth of the orbital debris population.

Since this was a workshop rather than a simple conference, following the formal presentations the attendees formed smaller working groups to address the principal orbital debris issues and to draft recommendations for future initiatives. One of the key consensus findings was the need to enhance orbital debris data collection efforts and to share the data with both scientists and engineers. Moreover, the data were seen as vital to the later crafting of effective and affordable debris mitigation policies. At the time, the magnitude of the known satellite population was only ~4500 large (> 10 cm) objects, about one-fifth of what it is today, and there were no credible estimates for the number of smaller, hazardous debris, which are now known to be in the millions.

The success of this NASA workshop was instrumental in the establishment of routine international gatherings to share data and thoughts on the orbital debris environment, especially at the annual International Astronautical Congresses and the biannual COSPAR Scientific Assemblies. ♦

PROJECT REVIEW

Coring the Wide Field Planetary Camera 2 Radiator for the Impactor Trace Residue Assessment

P. ANZ-MEADOR

After approximately 16 years in low Earth orbit, the Hubble Space Telescope Wide Field Planetary Camera 2 (WFPC-2) was returned to Earth in 2009 by the crew of STS-125's Servicing Mission 4. The WFPC2 radiator was exposed to the micrometeoroid (MM) and orbital debris (OD) environment and provided a unique witness to the environment due to this duration, as well as its relatively large 1.76 m^2 surface area. This surface was optically surveyed for impact features over the summer of 2009 by a NASA and contractor team drawn from the Johnson (JSC), Marshall (MSFC), and Goddard (GSFC) space centers. Approximately 700 features down to a limiting size of approximately 300 µm – estimated to correspond to a 100 µm OD projectile – were located and documented using a Keyence VHX-600 digital microscope (ODQN, January 2010, pp. 3-4; Apr 2010, pp. 5-6; January 2011, pp. 6-7).

The observed crater record will be used to bound the integrated flux but requires (1) a knowledge of the Hubble Space Telescope's attitude history, (2) damage equations to interpret the observed crater features on the WFPC2's surface as corresponding projectile size, and (3) a discrimination between the MM and OD components of the environment. This discrimination is required since the two

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WFPC2 Radiator Coring

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components possess quite distinct velocity, density, and directional distributions. Since the damage equations depend upon these variables, they must be inferred or determined by direct measurement to correctly implement the damage equations and thereby assess the MM and OD fluence.

The discrimination of the OD component uses Scanning Electron Microscope-Energy Dispersive X-ray (SEM-EDX) spectroscopy techniques to assess the elemental composition of the impactor. The elemental constituents thus reveal the impactor to be either MM or OD, or an indeterminate category. However, the WFPC2 radiator presents unique challenges due to its geometry (a rectangular section from a right circular cylinder's lateral surface), thickness (approximately 4 mm), coating (YB-71 Zinc Orthotitanate [ZOT] thermal control paint), and the size and extent of many impact features. Two major constraints are not contaminating the sample during collection, and not compromising the integrity of the cleanroom in which sampling would be conducted.

While a project team at JSC was determining the means of addressing these challenges, joint planning between JSC, GSFC, and the European Space Agency (ESA) was conducted to define requirements and schedules for collecting and analyzing impactor samples. The radiator was delivered to JSC and inserted into the Space Exposed Hardware (SEH) class 10,000 clean room in December 2011 concurrently with a joint project team meeting to kick off the sampling activity. This activity commenced in March 2012 and is expected to be completed by July, having collected over 450 core samples.

The Technique

A unique sampling tool was developed to perform cleanroom coring of the WFPC2 radiator impact features. The annular cutter is shown in Figure 1. In this case, a standard 5/8-inch- diameter (15.9 mm) cutting tool was modified with a concentric, spring-loaded, phosphor-bronze cylinder. The cylinder is tipped with a standard O-ring to protect the feature being cored. As the core drill is brought into contact with the radiator's surface, friction between the surface and the O-ring brings the cylinder to rest within the rotating annular cutter. As the cutter is advanced into the surface the cylinder retracts, allowing the radiator's aluminum substrate to be cut while protecting the feature of interest (shown in Figure 2).

Figures 3 and 4 illustrate the process by which cores are collected. The process begins with the identification of a feature to be cored. In Figure 3, team member Joe Caruana is aligning the core drill table roughly with a feature to be collected. The table allows four degrees of freedom in aligning the high torque drill motor assembly with the feature. After a rough alignment, the assembly is rotated to enter the radiator's surface normally, and fine positioning is achieved with a laser alignment system. In Figure 4, the cutter is engaging the surface. As the feature is protected, so is the cleanroom environment – visible here is a vacuum shroud around the cutter; dust generated by cutting is collected by a High-Efficiency Particulate Air (HEPA)-filtered vacuum while larger strands are collected by the shroud assembly itself. The cutter and shroud subsystems have performed very well during coring operations (note the number of cores taken from the surface, visible as dark circles in Figure 3).

After the core is inspected by team members, it is then stored in an aluminum rack for further analysis. The rack holds the cores firmly, while protecting and isolating the painted surface bearing the impact feature.

Analysis

During project planning it was agreed that the analysis would be shared by NASA and ESA. At JSC, the Astromaterials Research and Exploration Science (ARES) Directorate's SEM-EDX laboratory is charged with performing analyses to determine the elemental composition of impactors, and hence the source environment of the impactors, while the United Kingdom's Natural History Museum (NHM) was chosen as ESA's agent. The cores will be divided equally between NASA and ESA, becoming the laboratory sample property of each party. All core samples will be maintained in a state to allow future analyses on the cores, should superior

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Figure 1. The coring device developed at JSC, shown immediately after a coring test. Cores taken have a diameter (measured at the core's painted surface) of approximately 7 mm, corresponding to the inner diameter of the annular cutter. Minor paint flake abrasions are seen inside the cutter; other debris are contained within the vacuum shroud (shown in Figure 4). The device is cleaned and inspected after each operation.

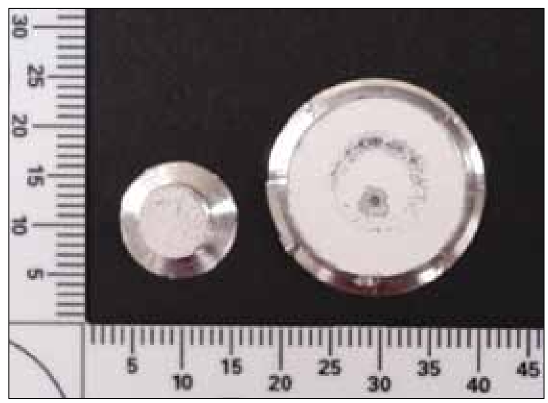

Figure 2. Small and large cores (taken with the cutter portrayed in Figure 1). Clearly visible on the surface of the large core is an impact crater displaying paint spallation. Also visible is an abrasion left by the large cutter's O-ring – this was later remedied by decreasing the cutter's spring constant.

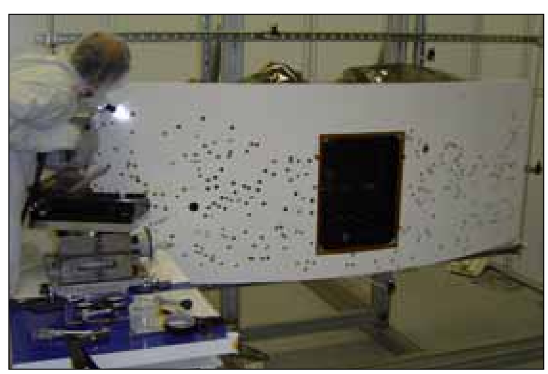

Figure 3. Preparation for coring a feature.

WFPC2 Radiator Coring

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techniques be developed and implemented for the analysis of returned surfaces.

Status

As of 1 July 2012, over 450 samples have been collected using the cutter shown in Figure 1. A larger cutter (1-1/16-inch- or 27-mm-diameter) is used to collect the largest features (including the area of spalled paint adjacent to the largest impact craters) and is currently collecting these large features, ending the collection phase of the project.

Following the collection phase, the radiator will be resurveyed using a pattern projection system, the LAP CADPro-3-D laser, to correlate collected features with the optical survey catalog developed in 2009. The radiator will be shipped back to GSFC for final disposition to the Smithsonian Institution's Air and Space Museum.

Analysis and Future Work

The ARES and NHM analytical teams are currently probing core samples to identify and record traces of impactor residue left in and about the impact features. Impactors from the MM and OD components have been identified, along with indeterminate results. In this latter case, a core can yield indeterminate results because no residues were present; no residues were identified; or in the case of craters resident only in the YB-71 paint layer, the crater geometry complicated electron beam-based instrumentation, confounding the investigation.

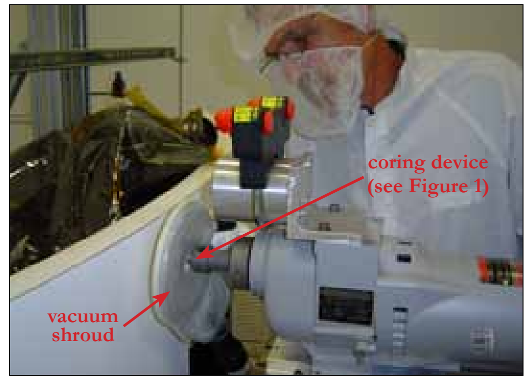

Figure 4. The vacuum shroud collects dust and chips during coring.

After the two impactor populations are identified, along with the indeterminate cases, population characteristics (density, relative velocity, and directional distributions) will be used in conjunction with damage equations to estimate the impactor's characteristic size. At that point, cumulative number or flux distributions of the MM and OD components begin to serve the modeling community. ♦

ABSTRACTS FROM THE NASA ORBITAL DEBRIS PROGRAM OFFICE

1st International Space Station (ISS) Research and Development Conference 26-28 June 2012, Denver, CO

Debris Impact Detection Instrument for Crewed Modules

J. OPIELA, R. CORSARO, F. GIOVANE, J.-C. LIOU

The goal of the Habitat particle Impact Monitoring System (HIMS) is to develop a fully automated, end-to-end, particle impact detection system for crewed space exploration modules. The HIMS uses multiple thin film vibration sensors to detect impacts on a surface, and computer processing of the acoustical signals to characterize the impacts. In tests, the HIMS located the point of impact to within 8 cm, provided a measure of the damage produced, and was insensitive to other acoustic events. This system will be completed and demonstrated as part of a crew "Caution/ Warning" system in concert with NASA's Habitat Demonstration Unit Project. ♦

39th COSPAR Scientific Assembly 14-22 July 2012, Mysore, India

Design of a Representative Low Earth Orbit Satellite to Improve Existing Debris Models

S. CLARK, M. WERREMEYER, A. DIETRICH, N. FITZ-COY, J.-C. LIOU, T. HUYNH, AND M. SORGE

This paper summarizes the process and methodologies used in the design of a small-satellite, DebriSat, that represents materials and construction methods used in modern day low Earth orbit (LEO) satellites. This satellite will be used in a future hypervelocity impact test with the overall purpose to investigate the physical characteristics of modern LEO satellites after an on-orbit collision. The major ground-based satellite impact experiment used by DoD and NASA in their development of satellite breakup models was conducted in 1992. The target used for that experiment was a Navy Transit satellite (40 cm, 35 kg) fabricated in the 1960s. Modern satellites are very different in materials and construction techniques from a satellite built 40 years ago. Therefore, there is a need to conduct a similar experiment using a modern target satellite to improve the fidelity of the satellite breakup models.

The design of DebriSat will focus on designing and building a "next-generation" satellite to more accurately portray modern satellites. The design of DebriSat included a comprehensive study of historical LEO satellite designs and missions within the past 15 years for satellites ranging from 10 kg to 5000 kg. This study identified modern trends in hardware, material, and construction practices utilized in recent LEO missions, and helped direct the design of DebriSat. This paper discusses the processes and procedures utilized in developing DebriSat. ♦

MEETING REPORT

The Second European Workshop on Active Debris Removal 18-19 June 2012, Paris, France

The national space agency of France, CNES, organized and hosted the Second European Workshop on Active Debris Removal (ADR) at the CNES HQ in Paris on June 18-19. Due to the overwhelmingly positive feedback after the first ADR Workshop in 2010, the event this year was extended to two full days. It attracted more than 120 participants from 11 European countries and representatives from Canada, Japan, and the United States. The objectives of the meeting were to promote the European awareness of the orbital debris problem and to encourage innovative concept and technology development for future ADR missions. The two-day activities included 37 technical presentations and several posters. From the context of the presentations, it is clear that significant progress has been made in various ADR areas since the last meeting – including concepts for removal, the overall mission design, systems requirements, technologies for on-orbit operations, and ground testing. Several organizations also described their upcoming technology demonstration missions during the workshop. ♦

UPCOMING MEETINGS

14-22 July 2012: The 39th COSPAR Scientific Assembly, Mysore, India

The theme for the space debris sessions for the 39th COSPAR is "Steps toward Environment Control." Topics to be included during the sessions are advances in ground- and space-based surveillance and tracking, in-situ measurement techniques, debris and meteoroid environment models, debris flux and collision risk for space missions, on-orbit collision avoidance, re-entry risk assessments, debris mitigation and debris environment remediation techniques and their effectiveness with regard to long-term environment stability, national and international debris mitigation standards and guidelines, hypervelocity impact technologies, and on-orbit shielding concepts. Additional information about the event can be found at <http://www.cospar-assembly.org/>.

11-14 September 2012: The 13th Advanced Maui Optical and Space Surveillance (AMOS) Technologies Conference, Maui, Hawaii

The 13th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS) will be held in Maui, Hawaii on 11-14 September 2012. This conference will provide a forum for sharing the latest research and technology developments in space surveillance and optics, and high performance computing. One of the technical sessions is dedicated to orbital debris. This year's AMOS will also include a keynote address by the Commander of Air Force Space Command, General William Shelton. Additional information about the conference is available at <http://www.amostech.com/>.

16-20 September 2012: The 2012 Hypervelocity Impact Symposium (HVIS), Baltimore, Maryland

This biennial event is organized by the Hypervelocity Impact Society to promote research and development in the high and hypervelocity impact areas. The topics to be covered in the 2012 HVIS include hypervelocity phenomenology, high-velocity launchers, spacecraft micrometeoroid and orbital debris shielding, material response and equation of state, fracture and fragmentation physics, analytical and numerical modeling, advanced and new diagnostics. Additional information about the symposium can be found at <http://hvis2012.org/>.

1-5 October 2012: The 63rd International Astronautical Congress (IAC), Naples, Italy

The theme for the 2012 IAC is "Space science and technology for the needs of all." Just like the previous IACs, a Space Debris Symposium is planned. It will address all aspects of space debris research and technology development. A total of six sessions are scheduled for the symposium on measurements, modeling and risk analysis, hypervelocity impacts and protection, mitigation and standards, and space debris removal issues. In addition, a joint session with the Space Security Committee on "Political, Economic, and Institutional Aspects of Space Debris Mitigation and Removal" will be held to address the non-technical issues associated with future debris removal. Additional information about the 63rd IAC can be found at <http://www.iac2012.org/>.

SATELLITE BOX SCORE

(as of 4 July 2012, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads	Rocket Bodies & Debris	Total
CHINA	126	3601	3727
CIS	1414	4694	6108
ESA	42	45	87
FRANCE	54	435	489
INDIA	47	127	174
JAPAN	121	74	195
USA	1169	3811	4980
OTHER	526	113	639
TOTAL	3499	12900	16399

Visit the NASA Orbital Debris Program Office Website

www.orbitaldebris.jsc.nasa.gov

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http://orbitaldebris.jsc.nasa.gov/

INTERNATIONAL SPACE MISSIONS

1 April 2012 – 30 June 2012

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2012-014A	USA 234	USA	NO ELEMS. AVAILABLE			0	0
2012-015A	PROGRESS-M 15M	RUSSIA	394	405	51.6	1	0
2012-016A	YAHSAT 1B	UAE	35779	35793	0.0	1	1
2012-017A	RISAT 1	INDIA	538	541	97.6	1	0
2012-018A	BEIDOU M3	CHINA	21461	21593	55.2	1	1
2012-018B	BEIDOU M4	CHINA	21452	21602	55.1		
2012-019A	AEHF 2 (USA 235)	USA	NO ELEMS. AVAILABLE			1	0
2012-020A	TIANHUI 1-02	CHINA	483	508	97.4	0	2
2012-021A	YAOGAN 14	CHINA	470	478	97.2	1	2
2012-021B	TIANTUO 1	CHINA	463	471	97.2		
2012-022A	SOYUZ-TMA 4M	RUSSIA	394	405	51.6	1	0
2012-023A	JCSAT 13	JAPAN	35777	35795	0.1	1	1
2012-023B	VINASAT 2	VIETNAM	35779	35795	0.1		
2012-024A	COSMOS 2480	RUSSIA	205	269	81.4	1	0
2012-025A	GCOM W1	JAPAN	701	704	98.2	1	3
2012-025B	KOMPSAT 3	S. KOREA	681	695	98.1		
2012-025C	SDS-4	JAPAN	662	673	98.2		
2012-025D	HORYU 2	JAPAN	653	669	98.2		
2012-026A	NIMIQ 6	CANADA	35766	35807	0.0	1	1
2012-027A	DRAGON C2/C3	USA	392	406	51.6	1	2
2012-028A	CHINASAT 2A	CHINA	35781	35792	0.1	1	0
2012-029A	YAOGAN 15	CHINA	1201	1207	100.1	1	0
2012-030A	INTELSAT 19	INTELSAT	35773	35800	0.1	1	0
2012-031A	NUSTAR	USA	614	634	6.0	1	0
2012-032A	SZ-9	CHINA	334	355	42.3	1	5
2012-032H	SZ-9 MODULE	CHINA	330	338	42.8		
2012-033A	USA 236	USA	NO ELEMS. AVAILABLE			0	0
2012-034A	USA 237	USA	NO ELEMS. AVAILABLE			1	0