National Aeronautics and Space Administration

Orbital Debris Quarterly News

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Inside...

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Space Debris Sensor On Orbit Status

The Space Debris Sensor (SDS), a Class 1E technical demonstrator payload, was robotically installed and activated aboard the International Space Station's (ISS's) *Columbus* module on 1 January 2018. Between activation and a failure to recover telemetry occurring on 26 January at approximately 0330 GMT, SDS gathered valuable technical data and recorded science data on 1312 acoustically-triggered events. At the current time, the SDS Engineering and Operations teams are actively engaged in troubleshooting the anomaly with support from NASA Johnson Space Center and Marshall Space Flight Center, the goal being to return SDS to service as soon as possible.

Technical data consists primarily of acoustic sensor and resistive grid measurements collected at a sampling rate of once per second. In many cases, these demonstrated better signal-to-noise performance on orbit than expected, though selected sensors do indicate signatures that may be indicative of orbit- or ISS local environment-related influences. The 1 Hz measurements of grid electrical resistance clearly indicate both orbit day/night cycles but also an asymptotic trend toward a baseline state; this may be due to bake-out or other acclimatization of the grids in their operational environment.

Science data is composed of coupled measurements of resistive grid line breaks for sufficiently large impactors, and medium data rate (500 kHz) acoustic (vibrational) data for each acoustically-triggered event. Of the over 1300 acoustic files, approximately 400 were collected during a test of lowering sensor threshold settings as a function of sensor noise and polling to declare an event. A second subset indicate sensor threshold excursions that were likely triggered by environmental conditions. A first analysis of the remaining events indicate three (3) credible events which triggered multiple acoustic sensors sufficient to triangulate an impact location; many more events triggered one or two sensors insufficient to determine a location, and perhaps indicative of smaller impactors. None of the three assessed impacts triggered SDS second- or third-layer sensors, and thus are hypothesized to be small impactors on the order of 50 micrometers, close to the lower limit of SDS sensitivity. There was no change in resistance associated with any of these three impacts, again consistent with the hypothesis of a small impactor. As both the micrometeoroid and orbital debris environments follow an approximate power law relationship in this size domain, small impactors are more likely to be encountered in any environment sampling.

The SDS team expects to resume in-depth analysis of the science and technical data following the completion of current troubleshooting and payload recovery activities. ♦

The SDS Operations and Engineering teams recognize the significant and on-going support provided to them by the ISS Program Office, the Joint Station Local Area Network (LAN) facility, and the NASA Marshall Space Flight Center's Payload Operations and Integration Center teams.

The 2018 UN COPUOS STSC Meeting

The UN Vienna International Centre, one of the four UN headquarters worldwide. Credit: UN Photo/Mark Garten

The Scientific and Technical Subcommittee (STSC) of the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) held its 55th session at the Vienna International Center from 29 January to 9 February 2018. Representatives from more than 70 COPUOS member States and a few dozen observer organizations attended the session. Bahrain, Denmark and Norway became the newest members of the Committee, increasing the COPUOS membership to 87 States. On the first day of the session, the Subcommittee officially adopted the agenda for the session, which included Space Debris, Space Weather, Near-Earth Objects, Long-Term Sustainability of Outer Space Activities (LTS), and other topics. The Subcommittee also elected Ms. Pontsho Maruping (South Africa) as its new Chair for the period 2018-2019.

Many member States expressed concerns at the challenges presented by space debris. The U.S. Statement on Space Debris emphasized the importance of the UN Space Debris Mitigation Guidelines and called on all space-faring nations, emerging space nations, international organizations, and non-government organizations around the world to implement these guidelines to limit the generation of space debris. Notable technical presentations on space debris during the session included "*U.S. Space Debris Environment, Operations, and Research Updates*," "*Space Debris Mitigation Activities at ESA in 2017*," and "*The Inter-Agency Space Debris Coordination Committee (IADC) - An overview of the IADC's annual activities*." All presentations are available at the UN COPUOS/STSC website: http://www.unoosa.org/oosa/en/ourwork/copuos/stsc/technical-presentations.html.

Established in 2010, the LTS Working Group (WG) has made significant progress developing consensus-based voluntary best-practice guidelines that can be implemented by States to help preserve outer space for current and future generations. The LTS WG reached a major milestone in 2016 when it finalized the first set of 12 LTS guidelines at the 59th COPUOS session (ODQN vol. 20, issue 4, October 2016, pp. 4-5). Since then, the LTS WG has continued to work on the preamble and the remaining proposed draft guidelines during the subsequent COPUOS, STSC, and special inter-sessional meetings. The LTS WG reached consensus on the preamble text and nine additional guidelines during the 2018 STSC session, a major accomplishment. The nine new guidelines are:

- Enhance the practice of registering space objects
- Provide updated contact information and share information on space objects and orbital events
- Perform conjunction assessment during all orbital phases of controlled flight
- Develop practical approaches for pre-launch conjunction assessment
- Promote and facilitate international cooperation in support of the long-term sustainability of outer space activities
- Share experience related to the long-term sustainability of outer space activities and develop new procedures, as appropriate, for information exchange
- Design and operation of space objects regardless of their physical and operational characteristics
- Take measures to address risks associated with the uncontrolled re-entry of space objects
- Observe measures of precaution when using sources of laser beams passing through outer space

Discussions will continue on the remaining seven proposed draft guidelines before the WG mandate expires at the end of the 2018 COPUOS session in June. ♦

Fragmentation of *Fregat-SB* Upper Stage Debris

The separable fuel/oxidizer tank discarded by a Fregat-SB upper stage fragmented on 12 February 2018 at approximately 0957GMT ± 2 minutes; the tank is associated with the Zenit-3F launch of Angola's AngoSat 1 geosynchronous communications satellite. The object (International Designator 2017-086C, U.S. Strategic Command [USSTRATCOM] Space Surveillance Network [SSN] catalog number 43089) is described in the SSN catalog as "FREGAT DEB (TANK)," one of five debris objects initially cataloged with this launch. Four of the debris objects, piece tags D, E, F, and G, are likely the launch vehicle second stage's solid rocket motor separation caps, and are typically observed with launches of the SL-23/*Zenit*-3F launch vehicle.

The Lavochkin *Fregat-SB* is based on the *Fregat* upper stage but adds a toroidal hypergolic fuel/oxidizer tank, the *sbrasyvaemye blok bakov* (SBB) and is variously referred to as the jettisoned tanks unit (JTU) or block (JTB), as shown in Fig. 1.

The tank accommodates two fuel and two oxidizer tanks, isolated by spherical bulkheads; unfortunately, at this writing, it is not clear if these are common bulkheads, as employed in the design of the similar Briz-M upper stage's auxiliary propellant tank. The fuel is unsymmetrical dimethylhydrazine (*UDMH*) while the oxidizer is nitrogen tetroxide (N_2O_4). These hypergolic components can explode on contact, indicating a possible failure mode. The JTU uses high pressure helium bottles to pressurize the tanks and devices to sever attachment and cabling to the *Fregat* upper stage body, perhaps indicative of additional failure modes. The reader is referred to a previous ODQN (ODQN vol. 20, Issues 1 & 2 (joint issue), April 2016, pp. 2-3) for a detailed description and illustrations of the *Fregat-SB* and SBB structures and particulars.

The SBB was in an orbit of approximately 4070 x 277 km altitude and an inclination of 50.4° at the time of the event. As of 5 March 2018, four additional "FREGAT DEB" objects associated

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Fragmentation

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with the event have entered the public catalog; these are pieces J-M (SSN 43219-22 inclusive) and Fig. 2 depicts their orbital evolution. All display relatively large area-to-mass ratios and one (piece L) has decayed from orbit. Up to 90 pieces, however, have been observed and the reader should note that the elliptical orbit and orbit plane orientation may complicate formal cataloging.

Reference

1. Marinin, I., *Novosti Kosmonavtiki* 2011 No. 3 (March 2011), pp. 27-28. ♦

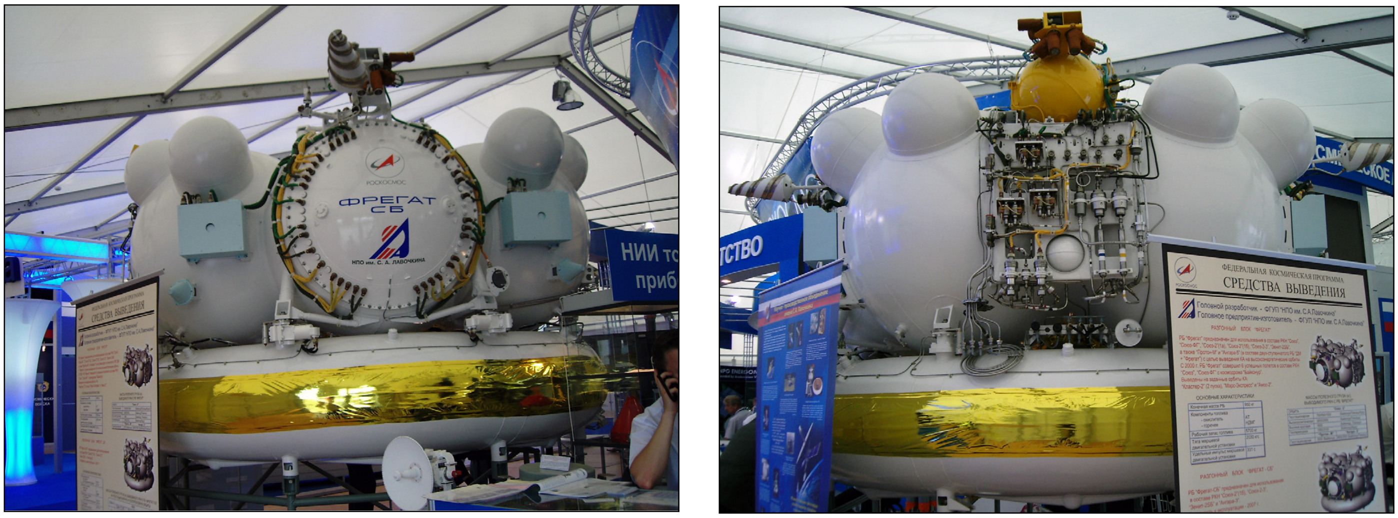

Figure 1. Two diametrically-opposed views of the Fregat-SB upper stage stack, as displayed at the MAKS 2005 aerospace show and exposition. Note that for flight units, the SBB's toroidal tank is wrapped in gold-colored multi-layer insulation rather than the likely reflective tape depicted here [Ref. 1]. Photos courtesy Nicolas Pillet.

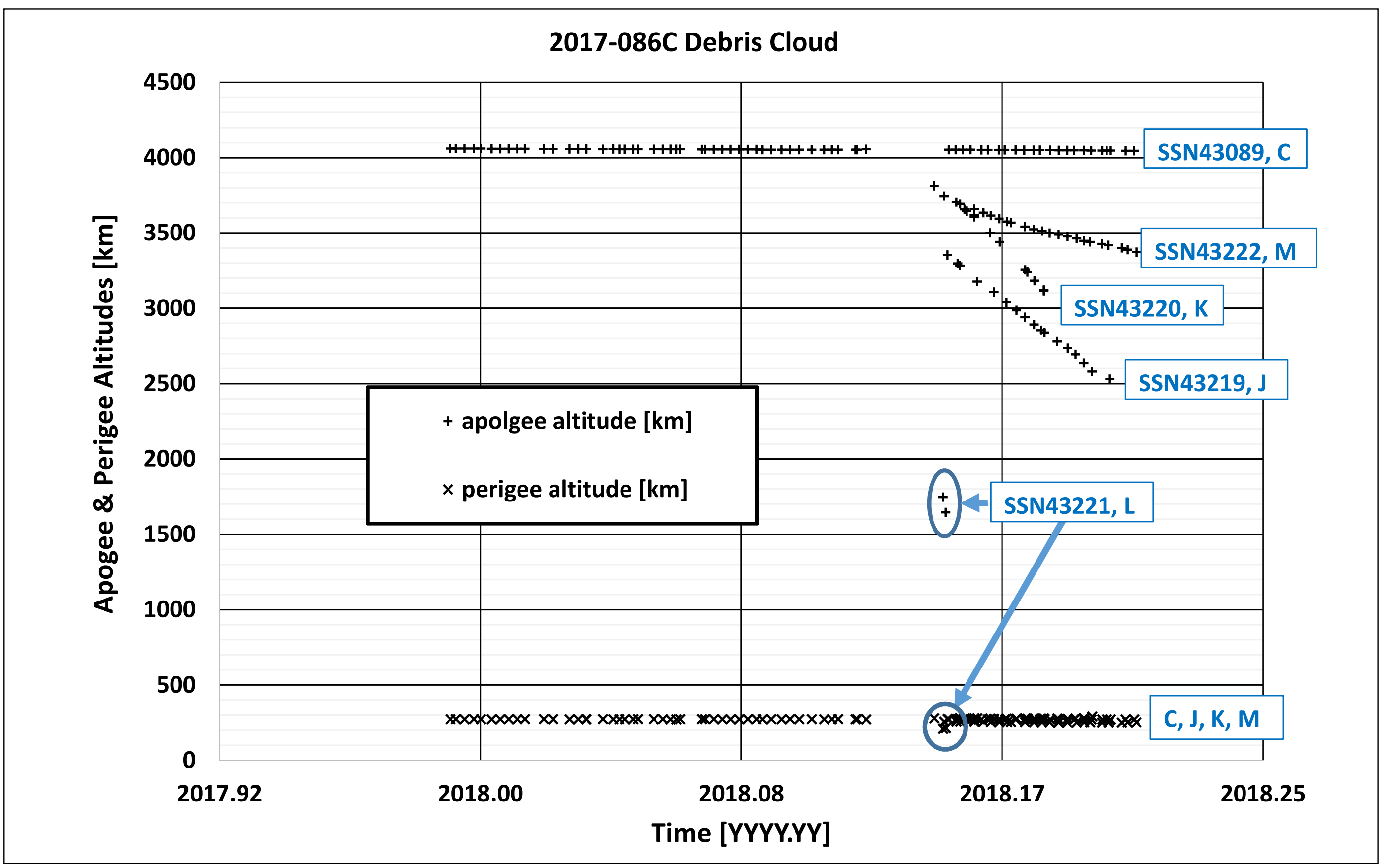

Figure 2. Orbital evolution of the cataloged SBB parent body (43089, C) and associated debris. The horizontal axis major divisions correspond to approximate calendar months of 1/12th year duration, and the event occurred at approximately 2018.116. The rate of orbital decay is indicative of a high area-to-mass (A/m) ratio object and suggestive of relatively "lightweight" debris objects, such as multi-layer insulation blankets. High A/m objects are subject to discernable radiation pressure forces in addition to atmospheric drag.

Fragmentation of Titan Transtage in GEO

In a previous ODQN (ODQN vol. 18, issue 3, July 2014, p. 2) we had reported the provisional breakup of a Titan Transtage rocket body (Space Surveillance Network [SSN] Catalog # 3692, International Designator 1969-013B) on 4 June 2014. At that time, five additional debris objects were thought to have been produced by the event; no objects entered the SSN catalog, however. Subsequent analysis conducted by US Strategic Command analysts indicated that this provisional breakup event may indeed have been an outgassing event, a rare but nonetheless recognized behavior in several rocket body classes.

A minor breakup has now been identified and associated with this rocket body. The event is estimated to have occurred at 2101 GMT on 28 February 2018, after approximately 49 years on-orbit. The rocket body was in a 6.23° inclined 37257 x 35886 km orbit. The approximately 1824 kg (dry mass) Transtage 3C-17 was the first Transtage launched to feature an active Heat Rejection System for stage thermal management and a monopropellant, anhydrous hydrazine (N_2H_4) Attitude Control System.

One fragment has been identified to date, having separated from the parent body at a relative velocity of approximately 71 m/s. Additional fragments may be cataloged in the future, and the reader is reminded that cataloging debris in the geosynchronous orbit is difficult. ♦

PROJECT REVIEWS

DebriSat Project Enters Data Reduction and Analysis Phase

H. COWARDIN, J.-C. LIOU, J. BACON, J. OPIELA, T. HUYNH, M. SORGE, AND N. FITZ-COY

The DebriSat project is a collaboration of the NASA Orbital Debris Program Office (ODPO), the Air Force Space and Missile Systems Center (SMC), The Aerospace Corporation (Aerospace), the University of Florida (UF), and the Air Force Arnold Engineering Development Complex (AEDC). The project has four primary goals: 1) design and fabricate a 56-kg flight-like spacecraft ("DebriSat") representative of modern spacecraft in the low Earth orbit (LEO) environment; 2) conduct a hypervelocity laboratory impact test to simulate a catastrophic fragmentation event of DebriSat; 3) collect and characterize all fragments down to 2 mm in size; and 4) use the data to improve space situational awareness applications and satellite breakup models for better orbital debris environment definition [1]. In 2014, the fabrication of DebriSat was completed and the hypervelocity laboratory impact test was successfully conducted [1]. The collection, measurement, and characterization of all fragments down to 2 mm in size has continued and plans are underway for the first set of laboratory-based radar and optical measurements to update the current radar-based Size Estimation Model (SEM) and to generate an optical SEM. The ultimate goal is to use the data and analysis to update existing breakup models used by NASA and the Department of Defense (DOD) and to support future Orbital Debris Engineering Model (ORDEM) development and damage assessments.

Motivation for the DebriSat project was provided by the need to update the Satellite Orbital Debris Characterization Impact Test (SOCIT), which was conducted by the DOD and NASA at AEDC in 1992 to support the development of satellite breakup models. The primary target for SOCIT was a fully functional U.S. Navy Transit 1960's era satellite. The DOD and NASA breakup models based on the SOCIT data have supported many applications and matched on-orbit events reasonably well over the years [1].

As new materials and construction techniques are developed for modern satellites, there is a corresponding need

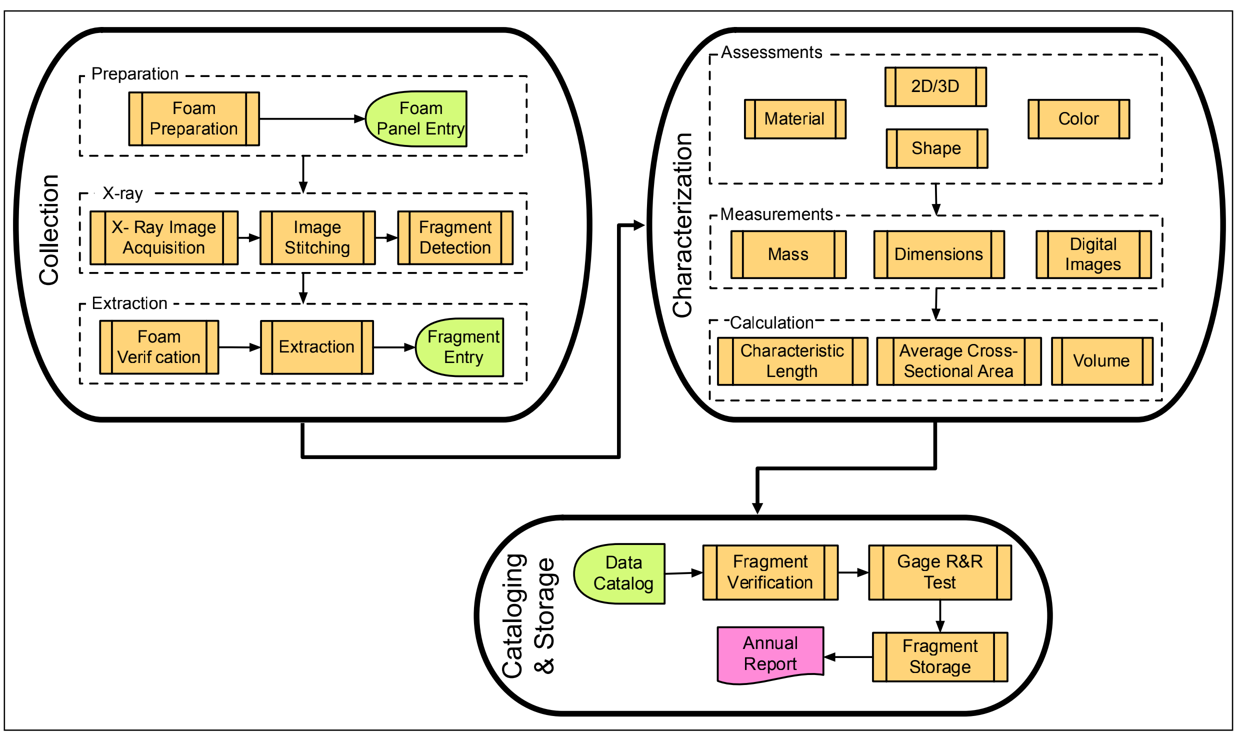

Figure 1. Collection-Characterization-Cataloging and Storage.

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DebriSat Project

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for new laboratory-based tests to acquire data to extend and improve existing DOD and NASA breakup models. The need for such tests also is justified by observed discrepancies between model predictions and observations of fragments generated from the breakup of modern satellites, including the Iridium 33 and Fengyun 1-C [2].

To support updates to break-up models, engineering models, and damage assessments the process is broken into three phases: collection, characterization, and verification, including measurement accuracy and repeatability (see Fig. 1) [3]. The collection stage entailed preparing the soft catch panels used to minimize secondary damage during the impact test for x-ray imaging, which is used to locate and extract embedded fragments. The soft catch arena was arranged with stacks of increasing density panels such that the lowest density was closest to the impact region. DebriSat used panels of three densities (low, medium, and high): 0.048, 0.096, and 0.193 g/cm^3. The panel stacks were about 25- to 60-cm thick, depending on the position inside the test chamber. The table shows the status of the extraction process as of publication.

Table - Panel Summary as of February 2018

Density Type	Number of Panels
PREPARATION	
All densities, full panels	382/588
All densities, broken panels	161
X-RAY IMAGING	
All densities	296/382
EXTRACTION	
All densities	282/296
Low density	78
Medium density	156
High density	48

The next step is fragment characterization. This process involves qualitative and quantitative assessments, both of which are crucial to analyzing the entire fragment population involved in a simulated LEO breakup event. The characterization process is broken into three major categories: assessment, measurement, and calculation. The initial characterization step involves assessing each uniquely identified fragment in terms of material, shape, color, and which imaging system the fragment qualifies for: two-dimensional (2D) or three-dimensional (3D) imaging. The 2D imaging system is primarily designed for flat objects, *i.e.*, those with a third dimension (height) that is negligible in comparison to the other two dimensions. The 3D imager is for larger objects that exceed the 2D imager threshold. Three dimensional imaging requires more time than the 2D system for data acquisition.

Mass and dimension measurements are directly acquired from the mass instrumentation and imaging system. The characteristic length, average cross-sectional area, and volume are all derived quantities stored with the uniquely identified fragment, as well as the images that were used in the 2D or 3D imaging process. To date, there are over 164,000 fragments collected with 143,680 currently recorded in the database. Historical growth of the number of collected and recorded fragments since the impact test is shown in Fig. 2. The original pre-impact-test estimate using the NASA breakup model predicted the number of 2 mm (and larger) fragments to be approximately 85,000, but this number has already been exceeded. The estimated number of fragments is now expected to surpass 250,000 (a factor of ~3 times the original estimate).

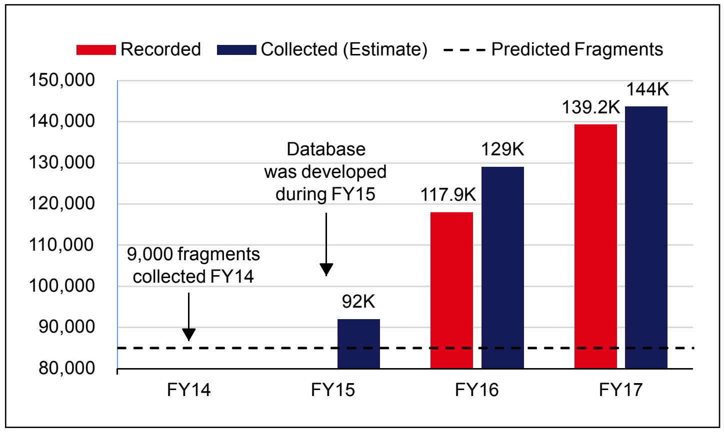

Figure 2. Historical plot of fragments collected from FY2014 through FY2017.

As the characterization process continues, subsets of the fragments will be selected for additional measurements in laboratory facilities. Using laboratory radar and optical facilities to collect ground-based sensor data will aid in the data interpretation used to create and update size estimation models.

Research also is underway at The Aerospace Corporation to quantify the effects of surface deposition on debris undergoing hyper-velocity impacts at various pressures to understand how albedo may vary due to environmental factors. Albedo, a measure of reflective efficiency, is a key term used in the current optical estimation of debris size from telescope data; therefore, employing various laboratory analyses will help refine the size estimates used in the development of the orbital debris engineering models.

The plan for laboratory measurements includes acquiring laboratory radar and optical measurements on the same DebriSat fragments. Measurements will be taken at multiple aspect angles over a large radar frequency sweep (2.4 – 18 GHz) and will cover a full optical broadband spectrum (300-1100 nm). The data will enable a comparative analysis between materials, shapes, and radar and optical signatures to improve multiple models. This will produce better size estimates of breakup fragments from space obejcts using modern materials. Compared to previous measurements that were conducted in the early 1990s, the larger sample set also promises greater confidence in the results.

Moving forward, the data from the laboratory analyses and parameters provided from the DebriSat charaterization process (refer to Fig. 1) will be used to update the NASA Standard Satellite Breakup Model (SSBM) and the DOD IMPACT model, which rely on accurate assessments of the fragments' size, mass, and the area-to-mass ratio distributions. In addition, the DebriSat data also will be used to develop bulk density and shape distributions for future ORDEM updates. These effects can be incorporated into ballistic limit equations to improve the fidelity of orbital debris impact risks assessments for space missions. Work currently is underway to investigate the shape effect using hypervelocity impact tests and hydrocode simulations.

References

1. Liou, J.-C., *et. al*. "Successful Hypervelocity Impacts of DebrisLV and DebriSat," *Orbital Debris Quarterly News*, vol. 18, issue 3, pp. 3-6, (2014).

2. Liou, J.-C. "An Update on Recent Major Breakup Fragments," *Orbital Debris Quarterly News*, vol. 13, issue 3, pp. 5-6, (2009).

3. Rivero, M., *et al.* "DebriSat Fragment Characterization System and Processing Status," IAC-16.A6.2.8x35593, 67th International Astronautical Congress, International Astronautical Federation, (2016). ♦

WORKSHOP REPORTS

The 4th International Space Debris Re-entry Workshop, 28 February – 1 March 2018, ESA/ESOC, Darmstadt, Germany

The 4th International Space Debris Re-entry Workshop was held from 28 February to 1 March in Darmstadt, Germany.

The workshop was hosted and run by Stijn Lemmens (ESA/ESOC Space Debris Office [OPS-GR]) with presentations covering a range of space debris topics. The first day was divided into three main sessions: "Orbital Lifetime Estimation," "Re-entry Prediction with Uncertainties," and "Re-entry Predictions on Catalogue Level." Day two included four main sessions: "Lower Thermosphere Orbit Observations and Orbit & Attitude Determination," "Atmospheric Break-up Physics: Experimentations," "Atmospheric Break-up Physics: Modelling," and "Re-entry Footprint Analysis." As of mid-March, all 37 workshop presentations were available at: https://reentry.esoc.esa.int/home/workshop.

The NASA Orbital Debris Program Office (ODPO) participated in the "Atmospheric Break-up Physics: Modeling" session with a presentation titled "ORSAT Modeling and Assessment." It provided an overview of the Object Reentry & Survivability Analysis Tool (ORSAT) including how ODPO uses it to assess NASA satellite mission compliance with reentry risk requirements.

Several presentations were of particular note given recent research interests within ODPO. One example is E. Stevenson's (ESA) presentation "Comparison of Atmosphere Models for Atmospheric Predictions" in which the predictive performance of atmospheric models used for orbital lifetime estimations was compared. Others are "Possible applications of AMOS meteor all-sky system for space debris reentry events detection and analysis" by J. Silha (Comenious University in Bratislava) and "PRISMA, an Italian all-sky camera surveillance network" by D. Gardiol (*Istituto Nazionale di Astrofisica*), which both present the potential for a large network of cameras that could be used to track space debris. Several presentations on reentry experiments may also be of interest to ODQN readers. The "Demise Observation Capsule: Development Status" by T. Watts (Science [&] Technology Corporation, S[&]T) presented an overview of a reentry capsule that has on-board data recorders and sensors to capture reentry data that could potentially be used for reentry analysis validation. In addition, several presentations focused on destructive tests and analysis of spacecraft components in reentry environments that provide some insight into the physical response of the components in representative aerothermal environments.

The 4th International Space Debris Re-entry Workshop was a valuable opportunity for representatives from many national space organizations to assemble and discuss modeling capabilities and the latest research interests. Stijn Lemmens concluded the meeting by noting the quality of work presented and the general enthusiasm of the industry to minimize uncertainties associated with space debris reentry. ♦

The 5th Annual Spacecraft Anomalies and Failures Workshop, 12-13 December, 2017 Chantilly, Virginia, USA

The 5th Annual Spacecraft Anomalies and Failures (SCAF) Workshop, co-sponsored by NASA and the U.S. National Reconnaissance Office (NRO), was held 12-13 December, 2017, in Chantilly, VA. It was attended by about 100 participants about equally split between government and industry. Over 20 presentations covered a diverse set of topics, but all discussions focused on how people, processes, and technologies may be leveraged to identify, characterize, and attribute anomalies of spacecraft as being caused by manmade or natural effects. However, this year emphasized that attribution (determining the root cause by component/subsystem) is manifested in validation of environmental and failure models; feedback into design and parts selection; and insights into vulnerability models. In other words, it is not sufficient to document lessons learned; we must "transform" lessons learned into the new context to fully exploit previous experiences to achieve these multiple benefits.

A desired outcome of a SCAF Workshop is to generate actionable items and this year it resulted in two major efforts:

- A definition is needed for "anomalies." The draft definition states that an anomaly is a functional perturbation to a satellite component, subsystem, or system that can be traced to a manmade or natural trigger.

  Even if the "anomaly" was expected, it is still an anomaly to the operations of that part of the satellite since these events aid not only in anomaly attribution but also model validation, design/parts refinement, and component/system vulnerability assessments.

- It was suggested that a draft "how to deal with satellite anomalies" as a best practice white paper or standard would be a valuable contribution to the community. A preliminary guideline for anomaly reporting has been drafted and is be refined. A copy is available from the ODQN editorial team upon request.

Next year, the workshop will strive to include more presentations from commercial operators, discuss policy on both days, include wider applications of artificial intelligence, include ground systems in the discussion of anomalies/failures of space systems, examine how human errors can manifest at many points along the life cycle of a satellite (not just operations), and report on technical "mysteries" solved during SCAF Workshop deliberations. ♦

UPCOMING MEETINGS

25-27 June 2018: 5th Workshop on Space Debris Modeling and Remediation, Paris, France

CNES Headquarters will host the 5th Workshop on Space Debris Modeling and Remediation. Topics are anticipated to include, but are not necessarily limited to, modeling, including specificities coming from small satellites and constellations; high level actions and road-maps associated with debris remediation; remediation system studies, including those relative to small debris; design of specific concepts, including new ideas relative to just-in-time collision avoidance and proposals devoted to large constellations and small satellites; concepts derived from current space tugs initiatives; GNC aspects, rendezvous sensors and algorithms, de-spin, control during de-boost; and policy, economics, insurance, intellectual property, national security, and international cooperation aspects of debris remediation. The abstract submission deadline passed on 15 March 2018. Additional information about the conference can be requested from Christophe Bonnal at CNES.

14-22 July 2018: COSPAR 2018, Pasadena, CA, USA

The 42nd Assembly of the Committee on Space Research (COSPAR) Scientific will convene in the Pasadena Convention Center on Saturday, 14 July 2018 and run through Sunday, 22 July. This assembly marks the 60th year of COSPAR. The COSPAR panel Potentially Environmentally Detrimental Activities in Space (PEDAS) will conduct a program entitled "Space Debris – Providing the Scientific Foundation for Action." PEDAS.1 sessions will include advances in ground- and space-based measurements of the orbital debris environment, micrometeoroid and orbital debris environment modeling, risk assessment, mitigation and remediation, hypervelocity impact range developments, and protection. The abstract submission deadline passed on 9 February 2018. Please see the COSPAR website at https://cosparhq.cnes.fr/content/cospar-2018 and the Assembly website at http://cospar2018.org/ for further information.

4-9 August 2018: 32nd Annual Small Satellite Conference, Logan, UT, USA

Utah State University (USU) and the AIAA will sponsor the 32nd Annual AIAA/USU Conference on Small Satellites at the university's Logan campus, Utah, USA. With the theme of "Delivering Mission Success," the 32nd conference will explore new technologies, design methods, processes, operational constructs, and activities that enhance the probability of success for small satellite missions. Session topics include assuring the space ecosystem, which will emphasize the interplay of small satellites and mission success to the sustainability of space, space situational awareness, space traffic management, and licensing and regulation. The abstract submission deadline passed on 8 February 2018. Additional information about the conference is available at https://www.smallsat.org.

11-14 September 2018: 19th Advanced Maui Optical and Space Surveillance Technologies Conference, Maui, Hawaii (USA)

The technical program of the 19th Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS) is anticipated to focus on subjects that are mission critical to Space Situational Awareness. The technical sessions include papers and posters on Orbital Debris, Space Situational Awareness, Adaptive Optics & Imaging, Astrodynamics, Non-resolved Object Characterization, and related topics. Additional information about the conference is available at https://amostech.com and this announcement will be updated in the ODQN as details become available.

1-5 October 2018: 69th International Astronautical Congress (IAC), Bremen, Germany

The IAC will convene in Bremen in 2018 with a theme of "IAC 2018 – involving everyone." The IAA will organize the 16th Symposium on Space Debris as session A6 during the congress. Nine dedicated sessions are planned to cover all aspects of orbital debris activities, including measurements, modeling, hypervelocity impact, mitigation, remediation, and policy/legal/economic challenges for environment management. An additional joint session with the section C1.7 Astrodynamics will be conducted. The abstract submission deadline passed on 28 February 2018. Additional information for the 2018 IAC is available at: https://www.iac2018.org/ .

SATELLITE BOX SCORE

(as of 04 April 2018, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

Country/ Organization	Payloads*	Rocket Bodies & Debris	Total
CHINA	289	3603	3892
CIS	1519	4995	6514
ESA	81	55	136
FRANCE	64	482	546
INDIA	88	117	205
JAPAN	172	106	278
USA	1670	4685	6355
OTHER	883	113	996
TOTAL	4766	14156	18922

** active and defunct*

Visit the NASA Orbital Debris Program Office Website

www.orbitaldebris.jsc.nasa.gov

Technical Editor
Phillip Anz-Meador, Ph.D.

Managing Editor
Debi Shoots

Correspondence concerning the ODQN can be sent to:

NASA Johnson Space Center
The Orbital Debris Program Office
Attn: JE104/Debi Shoots
Houston, TX 77058

debra.d.shoots@nasa.gov

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
2101 NASA Parkway
Houston, TX 77058

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

INTERNATIONAL SPACE MISSIONS

01 January – 31 March 2018

International Designator	Payloads	Country/ Organization	Perigee Altitude (KM)	Apogee Altitude (KM)	Inclination (DEG)	Earth Orbital Rocket Bodies	Other Cataloged Debris
2018-001A	USA 280	US	NO ELEMENTS AVAILABLE			0	0
2018-002A	SUPERVIEW-1 03	CHINA	519	529	97.6	1	4
2018-002B	SUPERVIEW-1 04	CHINA	515	534	97.6		
2018-003A	BEIDOU 3M3	CHINA	21513	21542	55.0	2	0
2018-003B	BEIDOU 3M4	CHINA	21517	21539	55.0		
2018-004A	CARTOSAT 2F	INDIA	505	511	97.5	1	1
2018-004C-T,V-AK	30 additional cubesats	Various					
2018-005A	USA 281	USA	NO ELEMENTS AVAILABLE			0	0
2018-006A	LKW-3	CHINA	490	501	97.3	0	4
2018-007A	ASNARO-2	JAPAN	497	500	97.4	1	1
2018-008A	XIAOXIANG 2	CHINA	522	548	97.5	1	0
2018-008B	ZHOU ENLAI	CHINA	525	548	97.5		
2018-008C	KEPLER-O (KIPP)	CANADA	526	549	97.5		
2018-008D	QUANTUTONG 1	CHINA	527	548	97.5		
2018-008E	JILIN-01-07	CHINA	527	548	97.5		
2018-008F	JILIN-01-08	CHINA	530	545	97.5		
2018-009A	SBIRS GEO 4 (USA 282)	USA	NO ELEMENTS AVAILABLE			0	0
2018-010A	DOVE PIONEER	USA	290	506	82.9	2	0
2018-010C	LEMUR 2 MARSHALL	USA	489	534	82.9		
2018-010E	LEMUR 2 TALLHAMN-ATC	USA	499	534	82.9		
2018-010F	HUMANITY STAR	NEW ZEALAND	172	179	82.9		
2018-011A	WEINA 1A	CHINA	597	602	35.0	1	0
2018-011B	YAOGAN-30 K	CHINA	595	604	35.0		
2018-011C	YAOGAN-30 L	CHINA	598	601	35.0		
2018-011D	YAOGAN-30 M	CHINA	597	602	35.0		
2018-012A	AL YAH 3	UAE	EN ROUTE TO GEO			1	1
2018-012B	SES 14	SES	EN ROUTE TO GEO				
2018-013A	SES-16/GOVSAT-1	SES	NO ELEMENTS AVAILABLE			1	0
2018-014A	KANOPUS-V 3	RUSSIA	507	509	97.5		
2018-014B	KANOPUS-V 4	RUSSIA	502	508	97.5		
2018-014C-K	8 additional small satellites	TBD					
2018-015A	FENGMANIU-1	CHINA	486	511	97.3	0	0
2018-015B	OBJECT B	TBD	492	503	97.2		
2018-015C	ZHANGZHENG-1	CHINA	489	517	97.3		
2018-015D	NUSAT 4	ARGN	484	510	97.3		
2018-015E	GOMX4-B	DEN	481	510	97.3		
2018-015F	GOMX4-A	DEN	481	510	97.3		
2018-015G	OBJECT G	TBD	437	508	97.2		
2018-015H	SHAONIAN XING	CHINA	482	509	97.3		
2018-015J	OBJECT J	TBD	452	499	97.5		
2018-015K	NUSAT 5	ARGN	483	510	97.3		
2018-016A	TRICOM-1R (TASUKI)	JAPAN	183	1624	30.9	1	0
2018-017A	TESLA ROADSTER/FALCON 9H	USA	HELIOCENTRIC ORBIT			0	0
2018-018A	BEIDOU 3M5	CHINA	21507	21549	55.0	2	0
2018-018B	BEIDOU 3M6	CHINA	21503	21553	55.0		
2018-019A	PROGRESS MS-08	RUSSIA	403	406	51.6	1	0
2018-020A	PAZ	SPAIN	507	510	97.5	1	0
2018-020B	TINTIN A	USA	498	519	97.5		
2018-020C	TINTIN B	USA	498	518	97.5		
2018-021A	IGS O-6	JAPAN	NO ELEMENTS AVAILABLE			1	2
2018-022A	GOES S	USA	35778	35795	0.0	1	0
2018-023A	HISPASAT 30W-6	SPAIN	35786	35788	0.0	1	0
2018-023B	PODSAT	USA	187	22205	27.1		
2018-024A	O3B FM15	O3B	8062	8070	0.1	1	0
2018-024B	O3B FM16	O3B	8062	8070	0.1		
2018-024C	O3B FM14	O3B	8062	8069	0.1		
2018-024D	O3B FM13	O3B	8062	8069	0.1		
2018-025A	OBJECT A	CHINA	488	502	97.3	0	1
2018-026A	SOYUZ MS-08	RUSSIA	403	406	51.6	1	0
2018-027A	GSAT 6A	INDIA	EN ROUTE TO GEO*			1	0
2018-028A	COSMOS 2525	RUSSIA	315	318	96.6	1	0
2018-029A	BEIDOU 3M7	CHINA	21522	21538	55.0	2	0
2018-029B	BEIDOU 3M8	CHINA	21543	22192	55.0		
2018-030A	IRIDIUM 148	USA	607	626	86.7	0	0
2018-030B	IRIDIUM 149	USA	608	626	86.7		
2018-030C	IRIDIUM 157	USA	608	626	86.7		
2018-030D	IRIDIUM 140	USA	607	626	86.7		
2018-030E	IRIDIUM 145	USA	607	626	86.7		
2018-030F	IRIDIUM 146	USA	608	627	86.7		
2018-030G	IRIDIUM 144	USA	607	626	86.7		
2018-030H	IRIDIUM 150	USA	608	627	86.7		
2018-030J	IRIDIUM 142	USA	607	626	86.7		
2018-030K	IRIDIUM 143	USA	653	670	86.6		
2018-031A	OBJECT A	CHINA	639	643	98.0		
2018-031B	OBJECT B	CHINA	634	642	98.0		
2018-031C	OBJECT C	CHINA	639	642	98.0		
2018-031D	OBJECT D	CHINA	641	647	98.0		
2018-031E	OBJECT E	CHINA	631	697	98.0		
2018-031F	OBJECT F	CHINA	491	648	98.1		
2018-031G	OBJECT G	CHINA	639	645	98.0		
2018-031H	OBJECT H	CHINA	593	647	98.1		
2018-031J	OBJECT J	CHINA	639	645	98.0		

* Payload currently unresponsive.