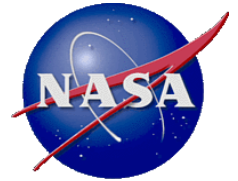


National Aeronautics and Space Administration



DebrisSat Project Update and Planning

M. Sorge, P.H. Krisko

**34th Inter-Agency Debris Coordination Committee
Oxford, U.K.
30 March – 2 April 2016**



DebrisSat Reporting Topics

- DebrisSat Fragment Analysis Calendar
- Near-term Fragment Extraction Strategy
- Fragment Characterization and Database
- HVI Considerations
- Requirements Document



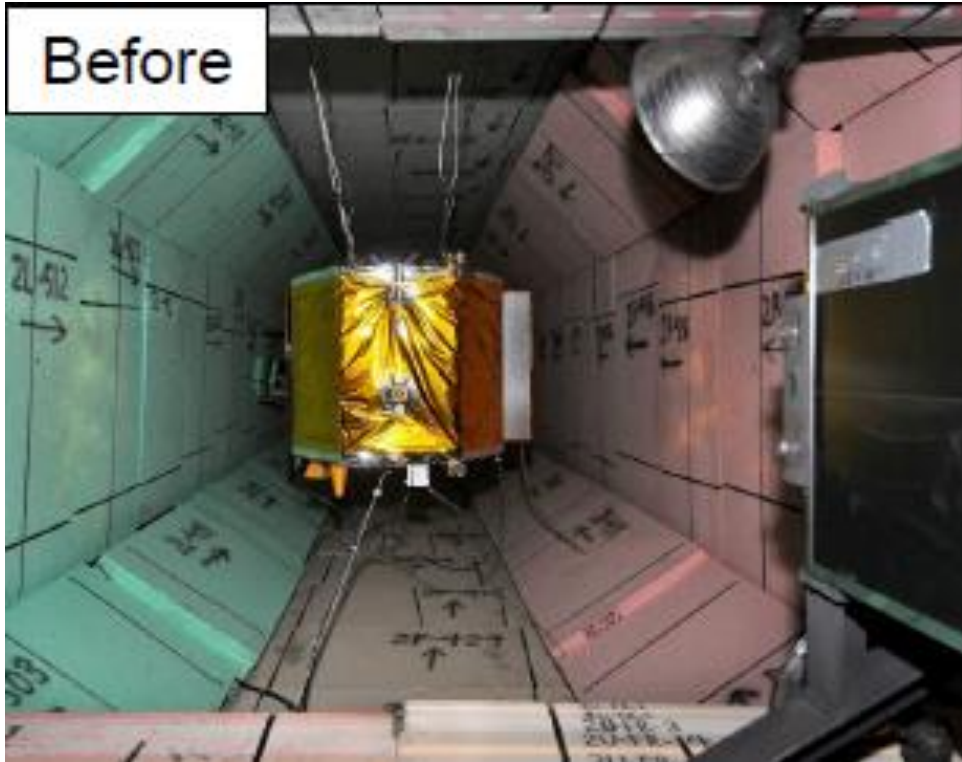
DebrisSat Fragment Analysis Calendar

- Post-test DebrisSat activity is concentrated on developing strategies and techniques to extract and categorize fragments through the current planned mission period.
- The panel X-ray task shown in the table below should be completed by the end of FY16 (09/30/16).
- Fragment extraction and characterization will continue throughout the duration of the project.
- DebrisLV activities are of lower priority, and may begin in FY17.

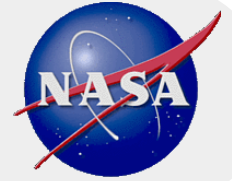
Task	FY 15				FY16				FY17				FY18			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
X-ray: DebrisSat	←															
Extraction: DebrisSat					←											
Characterization: DebrisSat	←															
X-ray: DebrisLV									←							
Extraction: DebrisLV													←			
Characterization: DebrisLV													←			



Near-term Fragment Extraction Strategy



- Pre-test foam panel placement is displayed in this DebrisSat before impact photo
 - Low-density polyurethane foam panels , each < 2" thick were installed inside target chamber one on top of the other (the most dense panel on the bottom)
 - Panel colors indicate position in the chamber only
 - Wide panels were placed horizontally and vertically
 - Narrow panels were placed at 45deg to allow nearly full coverage of the interior of the chamber
-
- A 30deg debris cone spread was expected by the operators to the end of the chamber
 - The next slide offers a cartoon push-out view of the panel placement with a progress report of panel preparation



UF Foam Panel Processing Plan UF as of 2/4/16

row 1

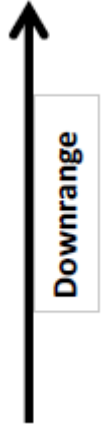
row 2

row 3

row 4

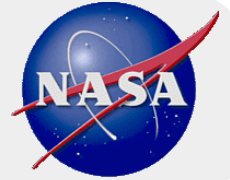
row 5

2L-101-0 2L-101-1 2L-101-2 2L-101-3 2L-101-4 2L-101-5 2L-101-6 2L-101-7 2L-101-8	2L-101-B 2L-112-0 2L-112-1 2L-112-2 2L-112-3 2L-112-4 2L-112-5 2L-112-6 2L-112-7 2L-112-8	2L-103-0 2L-103-1 2L-103-2 2L-103-3 2L-103-4 2L-103-5 2L-103-6 2L-103-7 2L-103-8	2L-103-B 2F-114-0 2F-114-1 2F-114-2 2F-114-3 2F-114-4 2F-114-5 2F-114-6 2F-114-7 2F-114-8	2R-105-0 2R-105-1 2R-105-2 2R-105-3 2R-105-4 2R-105-5 2R-105-6 2R-105-7 2R-105-8	2R-105-B 2R-116-0 2R-116-1 2R-116-2 2R-116-3 2R-116-4 2R-116-5 2R-116-6 2R-116-7 2R-116-8	2R-107-0 2R-107-1 2R-107-2 2R-107-3 2R-107-4 2R-107-5 2R-107-6 2R-107-7 2R-107-8	2R-107-B 2C-118-0 2C-118-1 2C-118-2 2C-118-3 2C-118-4 2C-118-5 2C-118-6 2C-118-7 2C-118-8
2L-201-0 2L-201-1 2L-201-2 2L-201-3 2L-201-4 2L-201-5 2L-201-6 2L-201-7 2L-201-8	2L-201-B 2L-212-0 2L-212-1 2L-212-2 2L-212-3 2L-212-4 2L-212-5 2L-212-6 2L-212-7 2L-212-8	2L-203-0 2L-203-1 2L-203-2 2L-203-3 2L-203-4 2L-203-5 2L-203-6 2L-203-7 2L-203-8	2L-203-B 2F-214-0 2F-214-1 2F-214-2 2F-214-3 2F-214-4 2F-214-5 2F-214-6 2F-214-7 2F-214-8	2R-205-0 2R-205-1 2R-205-2 2R-205-3 2R-205-4 2R-205-5 2R-205-6 2R-205-7 2R-205-8	2R-205-B 2R-216-0 2R-216-1 2R-216-2 2R-216-3 2R-216-4 2R-216-5 2R-216-6 2R-216-7 2R-216-8	2R-207-0 2R-207-1 2R-207-2 2R-207-3 2R-207-4 2R-207-5 2R-207-6 2R-207-7 2R-207-8	2R-207-B 2C-218-0 2C-218-1 2C-218-2 2C-218-3 2C-218-4 2C-218-5 2C-218-6 2C-218-7 2C-218-8
2L-301-0 2L-301-1 2L-301-2 2L-301-3 2L-301-4 2L-301-5 2L-301-6 2L-301-7 2L-301-8	2L-301-B 2L-312-0 2L-312-1 2L-312-2 2L-312-3 2L-312-4 2L-312-5 2L-312-6 2L-312-7 2L-312-8	2L-303-0 2L-303-1 2L-303-2 2L-303-3 2L-303-4 2L-303-5 2L-303-6 2L-303-7 2L-303-8	2L-303-B 2F-314-0 2F-314-1 2F-314-2 2F-314-3 2F-314-4 2F-314-5 2F-314-6 2F-314-7 2F-314-8	2R-305-0 2R-305-1 2R-305-2 2R-305-3 2R-305-4 2R-305-5 2R-305-6 2R-305-7 2R-305-8	2R-305-B 2R-316-0 2R-316-1 2R-316-2 2R-316-3 2R-316-4 2R-316-5 2R-316-6 2R-316-7 2R-316-8	2R-307-0 2R-307-1 2R-307-2 2R-307-3 2R-307-4 2R-307-5 2R-307-6 2R-307-7 2R-307-8	2R-307-B 2C-318-0 2C-318-1 2C-318-2 2C-318-3 2C-318-4 2C-318-5 2C-318-6 2C-318-7 2C-318-8
2L-401-0 2L-401-1 2L-401-2 2L-401-3 2L-401-4 2L-401-5 2L-401-6 2L-401-7 2L-401-8	2L-401-B 2L-412-0 2L-412-1 2L-412-2 2L-412-3 2L-412-4 2L-412-5 2L-412-6 2L-412-7 2L-412-8	2L-403-0 2L-403-1 2L-403-2 2L-403-3 2L-403-4 2L-403-5 2L-403-6 2L-403-7 2L-403-8	2L-403-B 2F-414-0 2F-414-1 2F-414-2 2F-414-3 2F-414-4 2F-414-5 2F-414-6 2F-414-7 2F-414-8	2R-405-0 2R-405-1 2R-405-2 2R-405-3 2R-405-4 2R-405-5 2R-405-6 2R-405-7 2R-405-8	2R-405-B 2R-416-0 2R-416-1 2R-416-2 2R-416-3 2R-416-4 2R-416-5 2R-416-6 2R-416-7 2R-416-8	2R-407-0 2R-407-1 2R-407-2 2R-407-3 2R-407-4 2R-407-5 2R-407-6 2R-407-7 2R-407-8	2R-407-B 2C-418-0 2C-418-1 2C-418-2 2C-418-3 2C-418-4 2C-418-5 2C-418-6 2C-418-7 2C-418-8
2L-501-0 2L-501-1 2L-501-2 2L-501-3 2L-501-4 2L-501-5 2L-501-6 2L-501-7	2L-501-B 2L-512-0 2L-512-1 2L-512-2 2L-512-3 2L-512-4 2L-512-5 2L-512-6 2L-512-7 2L-512-8	2L-503-0 2L-503-1 2L-503-2 2L-503-3 2L-503-4 2L-503-5 2L-503-6 2L-503-7	2L-503-B 2F-514-0 2F-514-1 2F-514-2 2F-514-3 2F-514-4 2F-514-5 2F-514-6 2F-514-7 2F-514-8	2R-505-0 2R-505-1 2R-505-2 2R-505-3 2R-505-4 2R-505-5 2R-505-6 2R-505-7	2R-505-B 2R-516-0 2R-516-1 2R-516-2 2R-516-3 2R-516-4 2R-516-5 2R-516-6 2R-516-7 2R-516-8	2R-507-0 2R-507-1 2R-507-2 2R-507-3 2R-507-4 2R-507-5 2R-507-6 2R-507-7	2R-507-B 2C-518-0 2C-518-1 2C-518-2 2C-518-3 2C-518-4 2C-518-5 2C-518-6 2C-518-7 2C-518-8



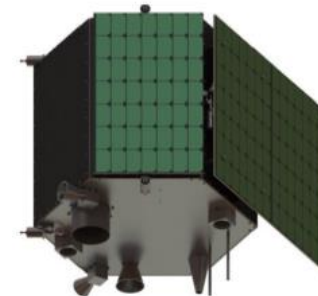
None / Unknown
Inspected
Preparing for X-ray
Ready for X-ray
Ready for Extraction / Completed X-ray
Extracting Fragments
Completed
Need to re-image

Panels are stacked sideways in figure
 Panel layers 0 (loose bagged material if any) and 1 (least dense on top) to 8 (densest panel on bottom)
 + is the pre-test position of DebrisSat in impact chamber
 Row 3 is chosen as the first chamber row, “ring” to be analyzed



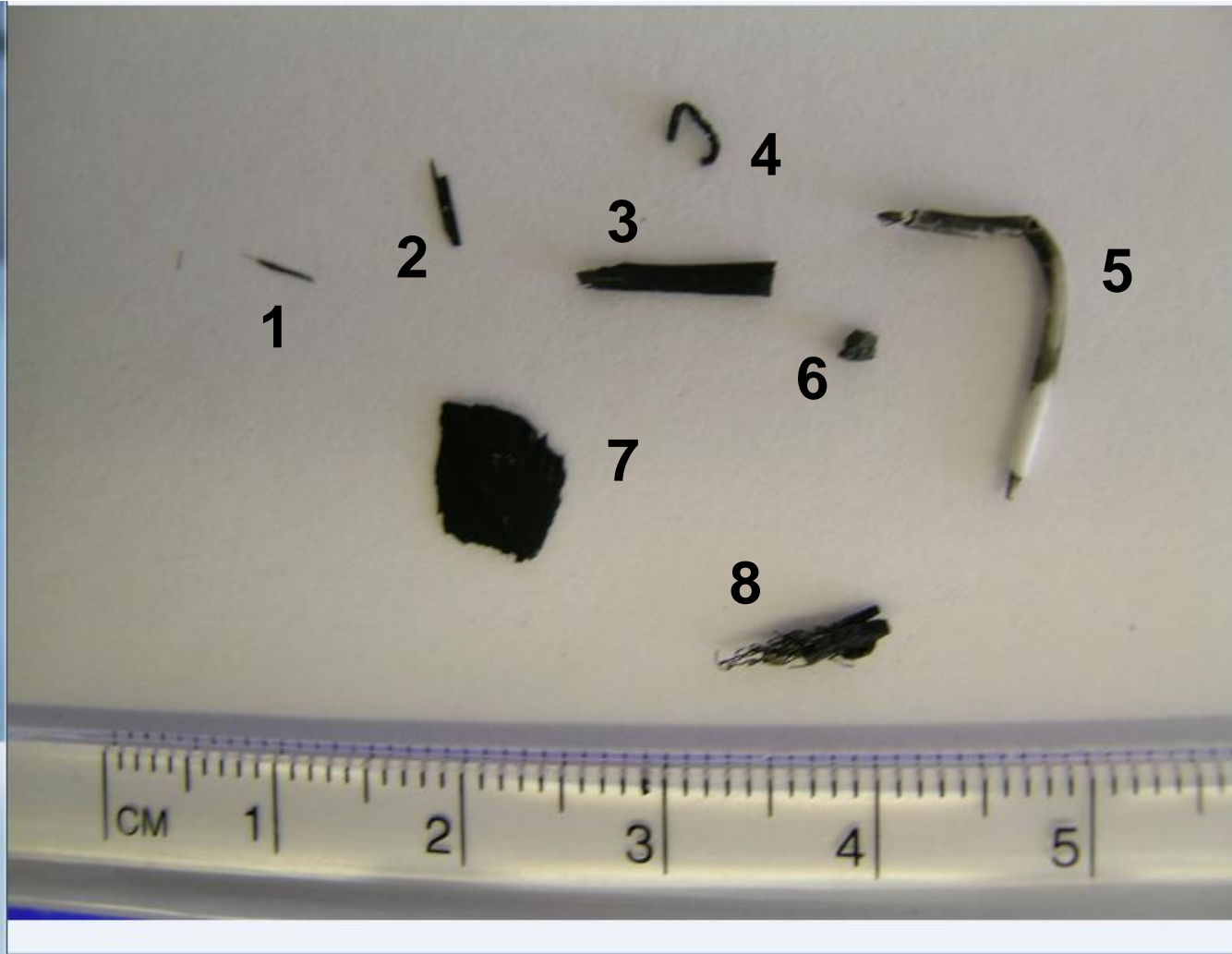
Fragment Characterization and Database

- The DebrisSat project group took care to build a spacecraft with components that mimic modern spacecraft.
- Plan is to extract ≥ 2 mm fragments from foam panels/loose pieces/dust
- Plan is to recover at least 90% of the total DebrisSat mass from the fragments
- Debris collected so far ~ 112 K, Debris recorded so far >107 K
- The current estimate for the ≥ 2 mm DebrisSat fragments to be collected is **more than 200,000**
 - Assign each individual fragment a unique identification number
 - A label of 2-D or 3-D is given to each fragment based on the means of analysis of fragment dimensions that will be performed
 - Fragment physical parameters filling out the database include material/color, shape
 - Fragment derived parameters include characteristic length, volume, average cross sectional area, mass, bulk density
- The small fragment population so far favors tens of thousands of CFRP (Carbon Fiber Reinforced Polymer) fragments created from the splintering DebrisSat spacecraft skin and interior inserts. These fragments favor the 2-D imaging techniques





Sample 2-D and 3-D Small Fragments

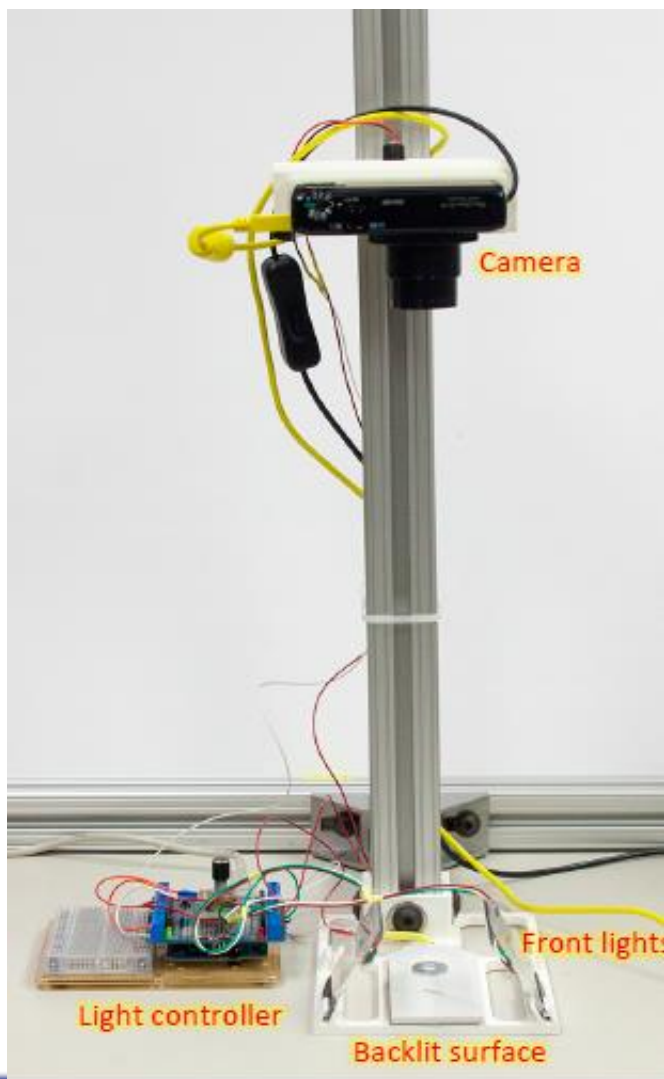


- Fragments labeled 1, 2, and 3 are CFRP splinters. These will be defined as 2-D objects.
- Wire fragments 4, 5 and the wire bundle (8) will likely be treated as 3-D.
- The nugget (6) and charred bent plate (7) are 3-D.
- The next slide displays the 2-D and 3-D apparatuses

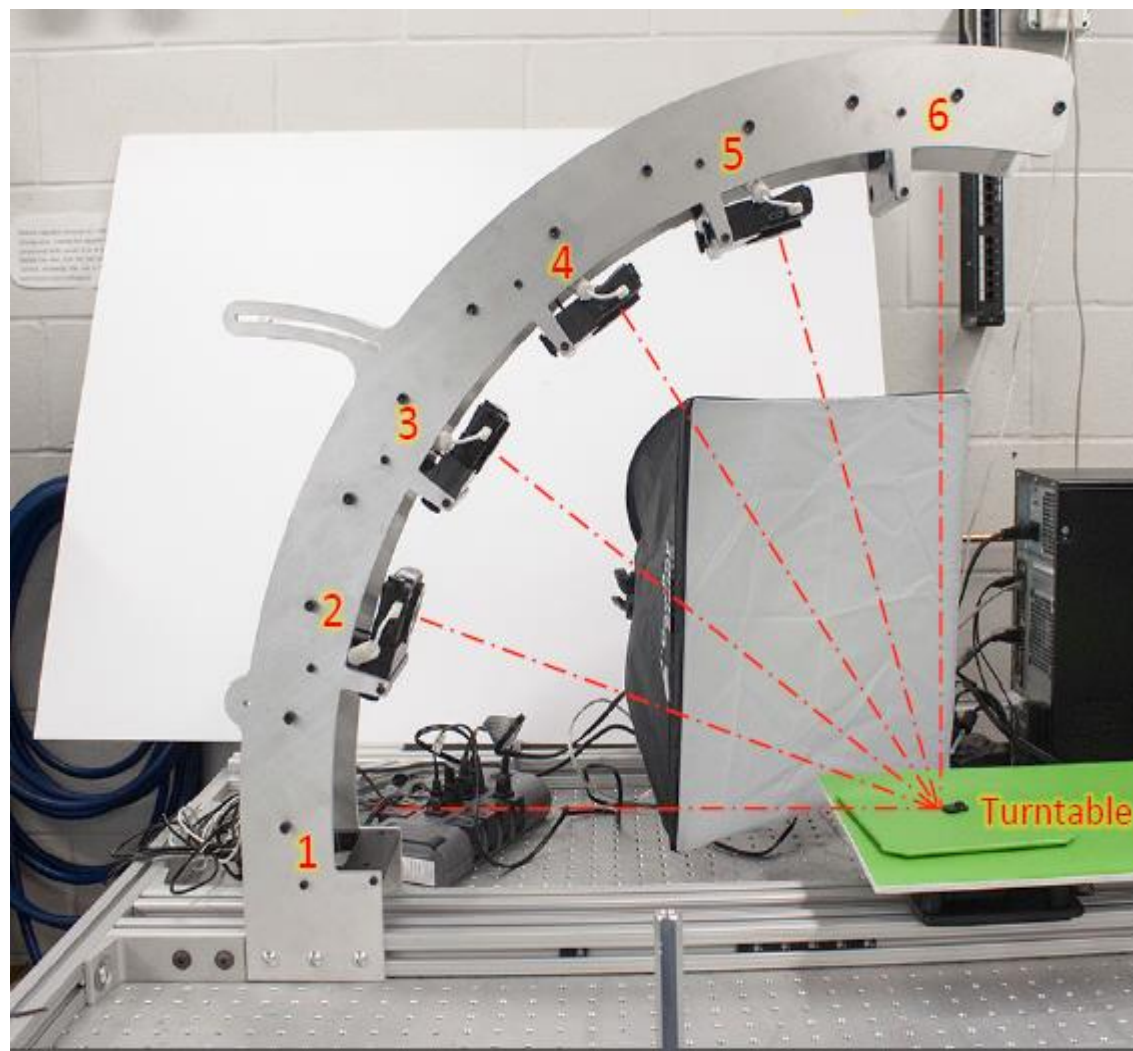


2-D vs 3-D

2-D Imaging



3-D Reconstruction





UF Database

- Investigating whether “needle-like fragment” dimensions (i.e., thickness is assumed to be negligible) can be approximated with simple 2-D assumption
- Further research is required to determine what the average thickness of the CFRP fragments are, to provide a range of expected thicknesses



UF Database (Homepage)

UF Debris Categorization System

Logged in as: joeykleespies Debris ID: [View Debris](#)

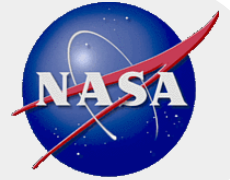
Project: **DebrisSat** [Add Debris](#) Rows per page: 10 [Hide Verified](#)

ID	R	CREATOR	TIMESTAMP								
DS000001	0	X-38	joeykleespies	08-09-2015, 11:17 am	✓	✗	✗	✗	✗	✗	✗
DS000002	0	X-38	joeykleespies	12-03-2014, 11:01 am	✓	✗	✗	✗	✗	✗	✗
DS000003	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000004	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000005	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000006	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000007	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000008	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000009	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗
DS000010	0	X-60	joeykleespies	12-03-2014, 11:02 am	✓	✗	✗	✗	✗	✗	✗

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© 2010 University of Florida Version: 1.0.2 Build: 111215 Designed by Joe Kleespies

- UF database plans to include single-tagged fragments $\geq 2\text{mm}$ in maximum dimension, original locations within panels, material, shape, mass, volume, CS area, characteristic length, and multiple photos



UF Database (ID, Locations, Measurements)

University of Florida - DCI x
10.244.15.144/dcs/secured/add_debris.php

UF UNIVERSITY OF FLORIDA
Debris Categorization System

NASA JACOBS

Add Debris Logged in as: joeykleespies

Home
Debris
Foam
Logout

IDENTIFICATION
Project: DebiSat Box #:

LOCATION
Source: Section: Section 5 Row: Area:
Related Foam Panel:

MEASUREMENTS
Material: Shape:
Mass: g Volume: mm³ Density: g/mm³
X_{DDM}: mm Y_{DDM}: mm Z_{DDM}: mm
L_{CHAR}: mm CS Area: mm²

MISCELLANEOUS
Foam Attached:



HVI Considerations

- Fragments in the UF Database are categorized by specific subjective criteria, for example, material, shape, size, color, location in panels) for the purpose of estimating lethality of these fragments in on-orbit collisions
 - In many cases their respective origins can not be determined with certainty.
 - CFRP highlight in the end. Invisible to radar....

Shape
flat plate
bent plate
straight/needle/rod/cylinder
bent/needle/rod/cylinder
parallelepiped/nugget/spheroid
flexible /MLI

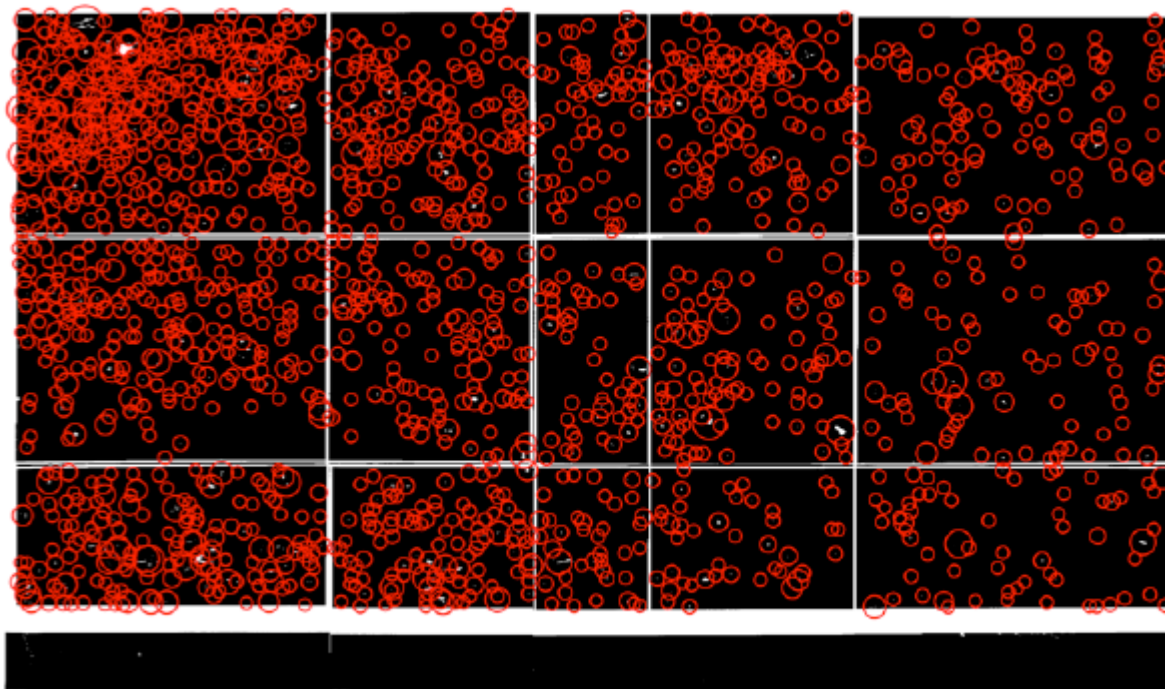
Color
silver
red
black
gold
light blue
royal blue
magenta
clear
burnt/charred

Material
aluminum
stainless Steel
glass
printed circuit board
copper
MLI/kapton
carbon fiber
plastic
multi-material



HVI Considerations

Debris Detection Software and Fragment Extraction



CAD model of
Debrisat without
MLI Test Plan
2014-03-13

