DebriSat Project Update and Planning

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Oxford, U.K.
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DebriSat Reporting Topics

- DebriSat Fragment Analysis Calendar
- Near-term Fragment Extraction Strategy
- Fragment Characterization and Database
- HVI Considerations
- Requirements Document
Post-test DebriSat 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.

<table>
<thead>
<tr>
<th>Task</th>
<th>FY 15</th>
<th>FY16</th>
<th>FY17</th>
<th>FY18</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray: DebriSat</td>
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<tr>
<td>Extraction: DebriSat</td>
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<tr>
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Near-term Fragment Extraction Strategy

- Pre-test foam panel placement is displayed in this DebriSat 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
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 DebriSat in impact chamber

Row 3 is chosen as the first chamber row, “ring” to be analyzed

None/Unknown
Prepared
Preparing for X-ray
Ready for X-ray
Ready for Extraction / Completed X-ray
Extracting Fragments
Completed
Need to re-image
The DebriSat project group took care to build a spacecraft with components that mimic modern spacecraft.

Plan is to extract $\geq 2$ mm fragments from foam panels/loose pieces/dust

Plan is to recover at least 90% of the total DebriSat mass from the fragments

Debris collected so far $\sim 112K$, Debris recorded so far $>107K$

The current estimate for the $\geq 2$mm DebriSat 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 DebriSat spacecraft skin and interior inserts. These fragments favor the 2-D imaging techniques.
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 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

Camera
Light controller
Backlit surface
Front lights

3-D Reconstruction

Camera
Light controller
Backlit surface
Front lights
Turntable
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 plans to include single-tagged fragments $\geq 2$mm in maximum dimension, original locations within panels, material, shape, mass, volume, CS area, characteristic length, and multiple photos.
UF Database (ID, Locations, Measurements)
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 cannot be determined with certainty.
  - CFRP highlight in the end. Invisible to radar….

<table>
<thead>
<tr>
<th>Shape</th>
<th>Color</th>
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<tbody>
<tr>
<td>flat plate</td>
<td>silver</td>
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<tr>
<td>bent plate</td>
<td>red</td>
</tr>
<tr>
<td>straight/needle/rod/cylinder</td>
<td>black</td>
</tr>
<tr>
<td>bent/needle/rod/cylinder</td>
<td>gold</td>
</tr>
<tr>
<td>parallelepiped/nugget/spheroid</td>
<td>light blue</td>
</tr>
<tr>
<td>flexible / MLI</td>
<td>royal blue</td>
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<tr>
<td></td>
<td>magenta</td>
</tr>
<tr>
<td></td>
<td>clear</td>
</tr>
<tr>
<td></td>
<td>burnt/charred</td>
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<table>
<thead>
<tr>
<th>Material</th>
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<tbody>
<tr>
<td>aluminum</td>
</tr>
<tr>
<td>stainless Steel</td>
</tr>
<tr>
<td>glass</td>
</tr>
<tr>
<td>printed circuit board</td>
</tr>
<tr>
<td>copper</td>
</tr>
<tr>
<td>MLI/kapton</td>
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<tr>
<td>carbon fiber</td>
</tr>
<tr>
<td>plastic</td>
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<tr>
<td>multi-material</td>
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HVI Considerations
Debris Detection Software and Fragment Extraction

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