National Aeronautics and Space Administration

DebriSat Project Status

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ODRSO Lead R&D
JACOBS JETS Contract
In support of the NASA Orbital Debris Program Office

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Outline

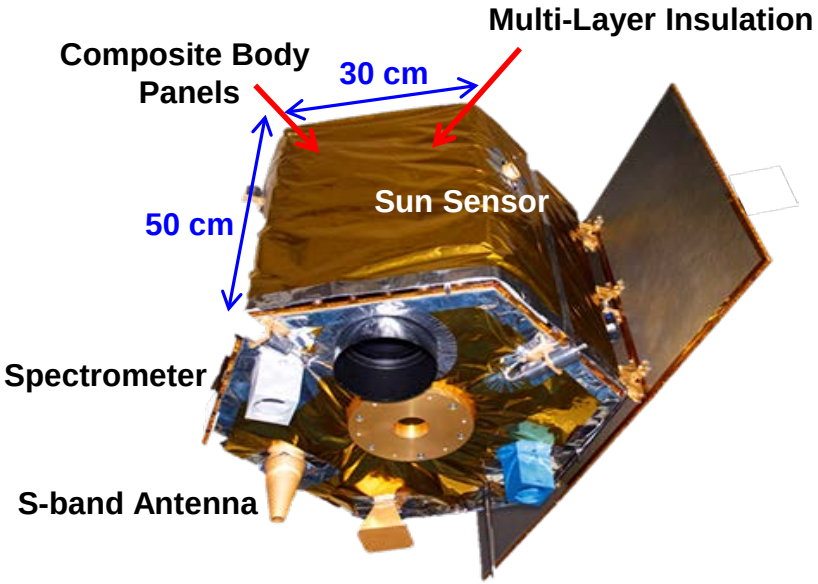
- **DebriSat Project Overview**
- **Status**
- **Plan Forward**

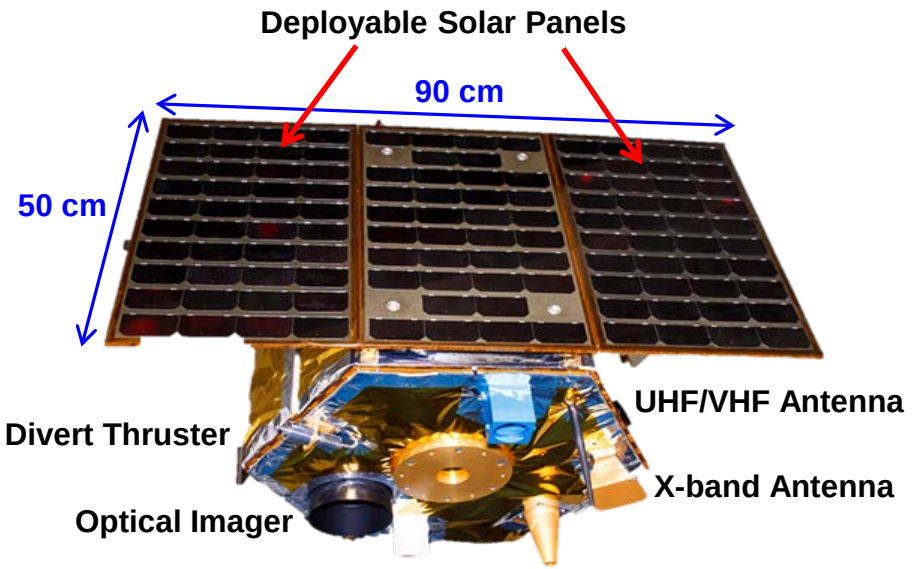
DebriSat Project Team

- **NASA Orbital Debris Program Office (ODPO)**
  - Co-sponsor, project and technical oversight, data collection, data analyses, NASA model improvements
- **AF Space and Missile Systems Center (SMC)**
  - Co-sponsor, technical oversight
- **The Aerospace Corporation (Aerospace)**
  - DebriSat design support, DebrisLV design & fabrication, data collection, data analyses, DoD model improvements
- **University of Florida (UF)**
  - DebriSat design & fabrication, data collection, fragment processing and characterization
- **AF Arnold Engineering Development Complex (AEDC)**
  - Hypervelocity impact tests

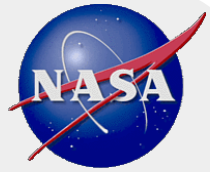
Brief Intro

- The purpose of the DebriSat project is to replicate a hyper-velocity fragmentation event using modern-day spacecraft materials and construction techniques to better improve the existing DoD and NASA breakup models





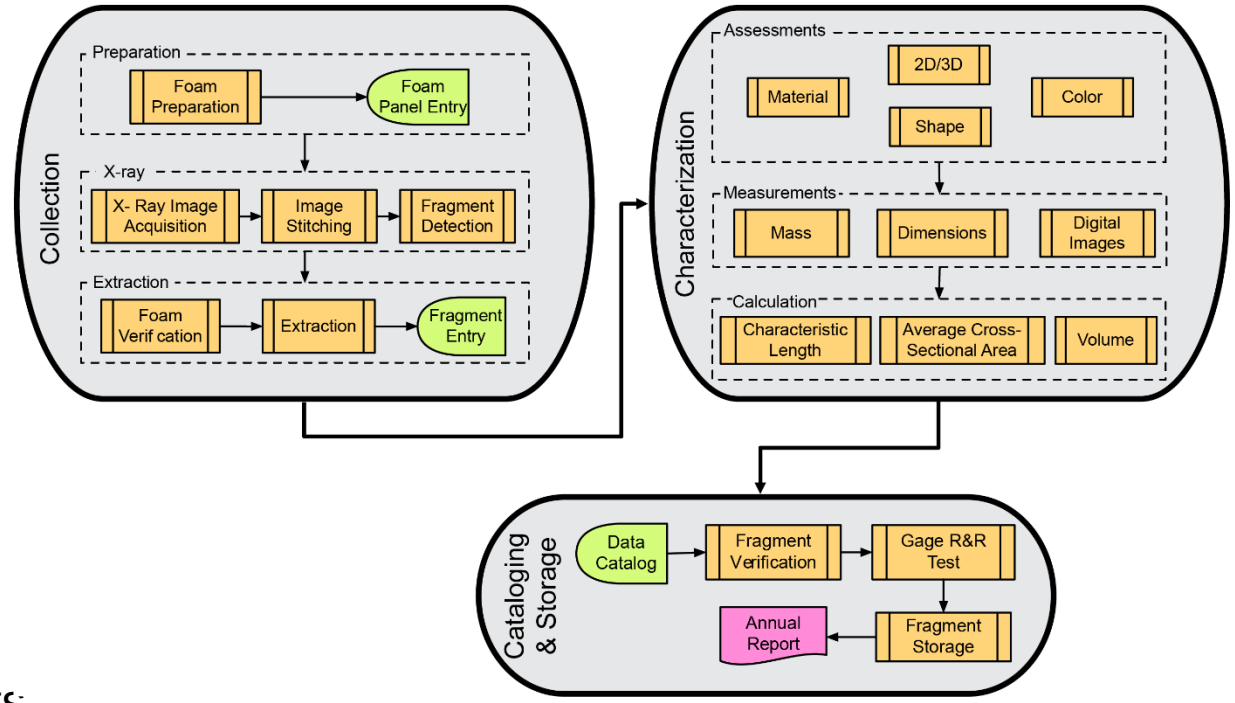
DebriSat Project Motivation



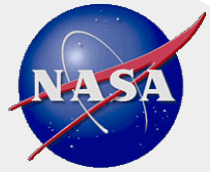
- **The need for laboratory-based impact tests was recognized by DoD and NASA decades ago**
- **Key impact test series, Satellite Orbital Debris Characterization Impact Test (SOCIT) was conducted by the Department of Defense (DOD) and NASA at AEDC in 1992 to support the development of satellite breakup models**
- **Breakup models based on SOCIT have supported many applications over the years**
- **As new materials and construction techniques are developed for modern satellites, there is a need for new laboratory-based tests to acquire data to improve the existing DoD and NASA breakup models and support space situational awareness (SSA) applications**

Fragment Characterization Plan

- **Collect, measure, and characterize all fragments, including MLI and solar panel pieces, down to ~2 mm in size**
- **Conduct radar, photometric, and spectral measurements for selected fragments**
  - Support improvements to radar and optical size-estimation models



DebriSat Project Milestones
Collection-Characterization-Application



2014-present
- Fragment processing and characterization

Sep 2016
- Delivery of first set of measurement data

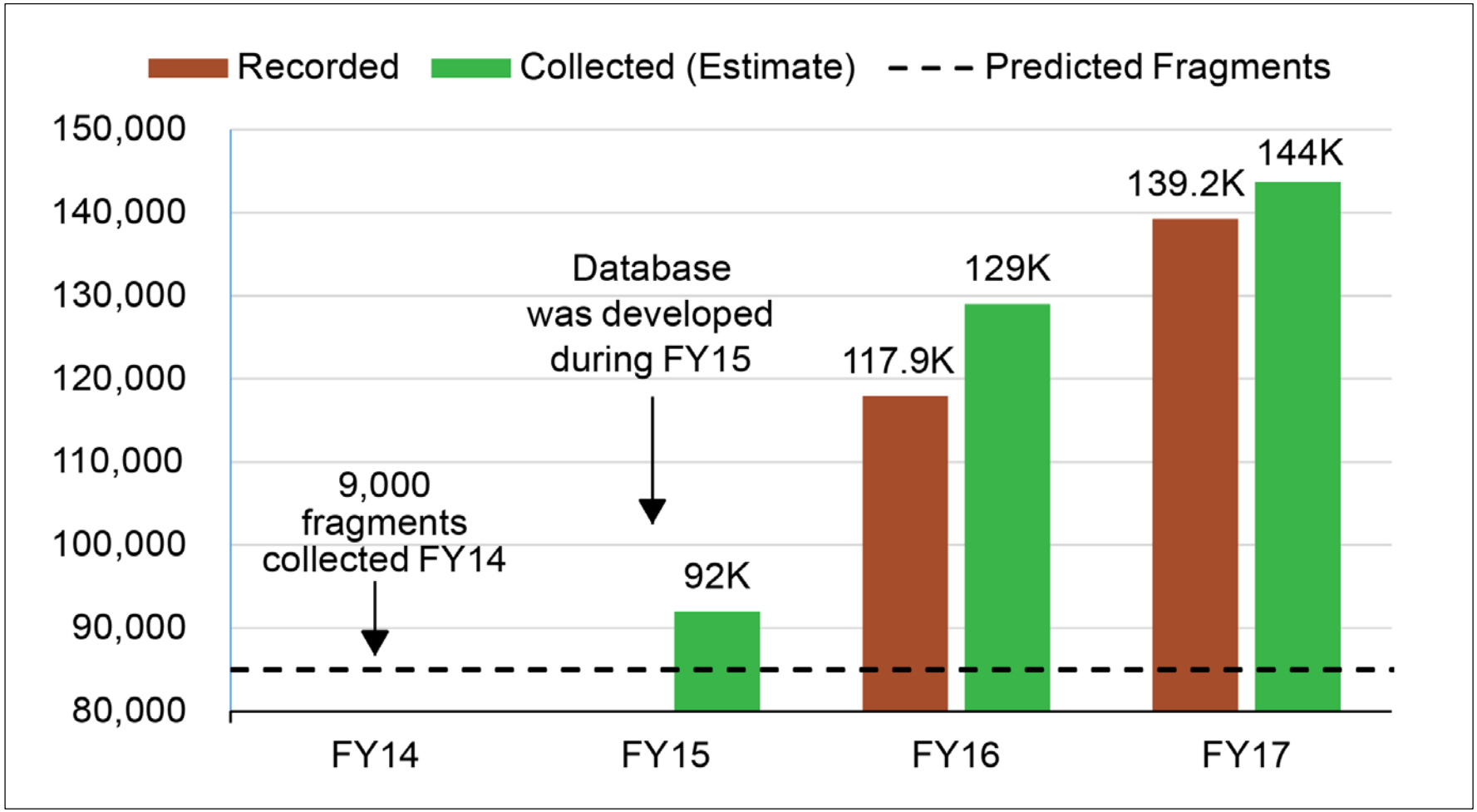
2016-2017
- Initial data analyses for model improvements

2018-2019
- Fragment radar and optical measurements

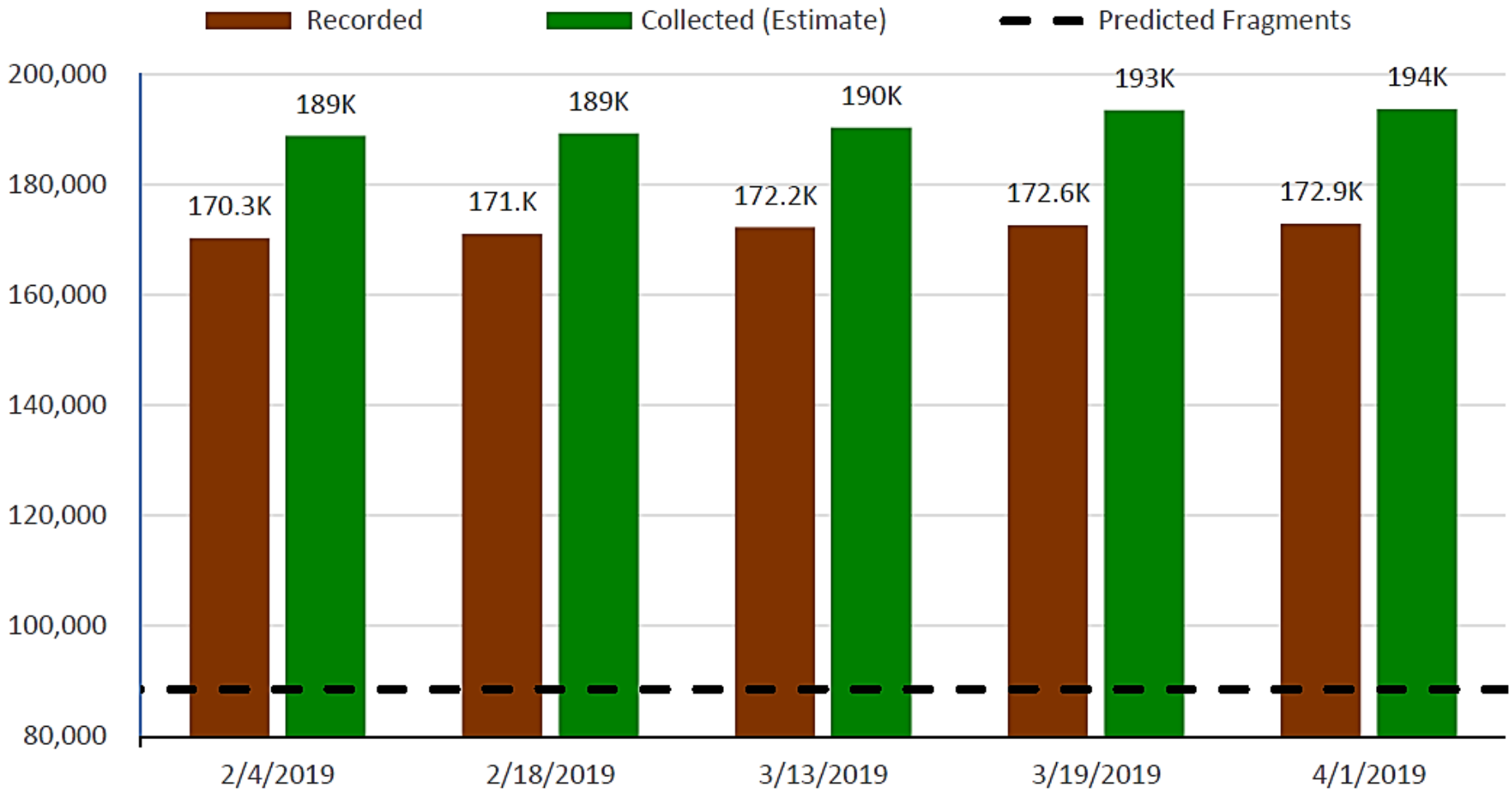
Sep 2020
- Complete measurement data

2018-2020
- Debris model and SSA application updates

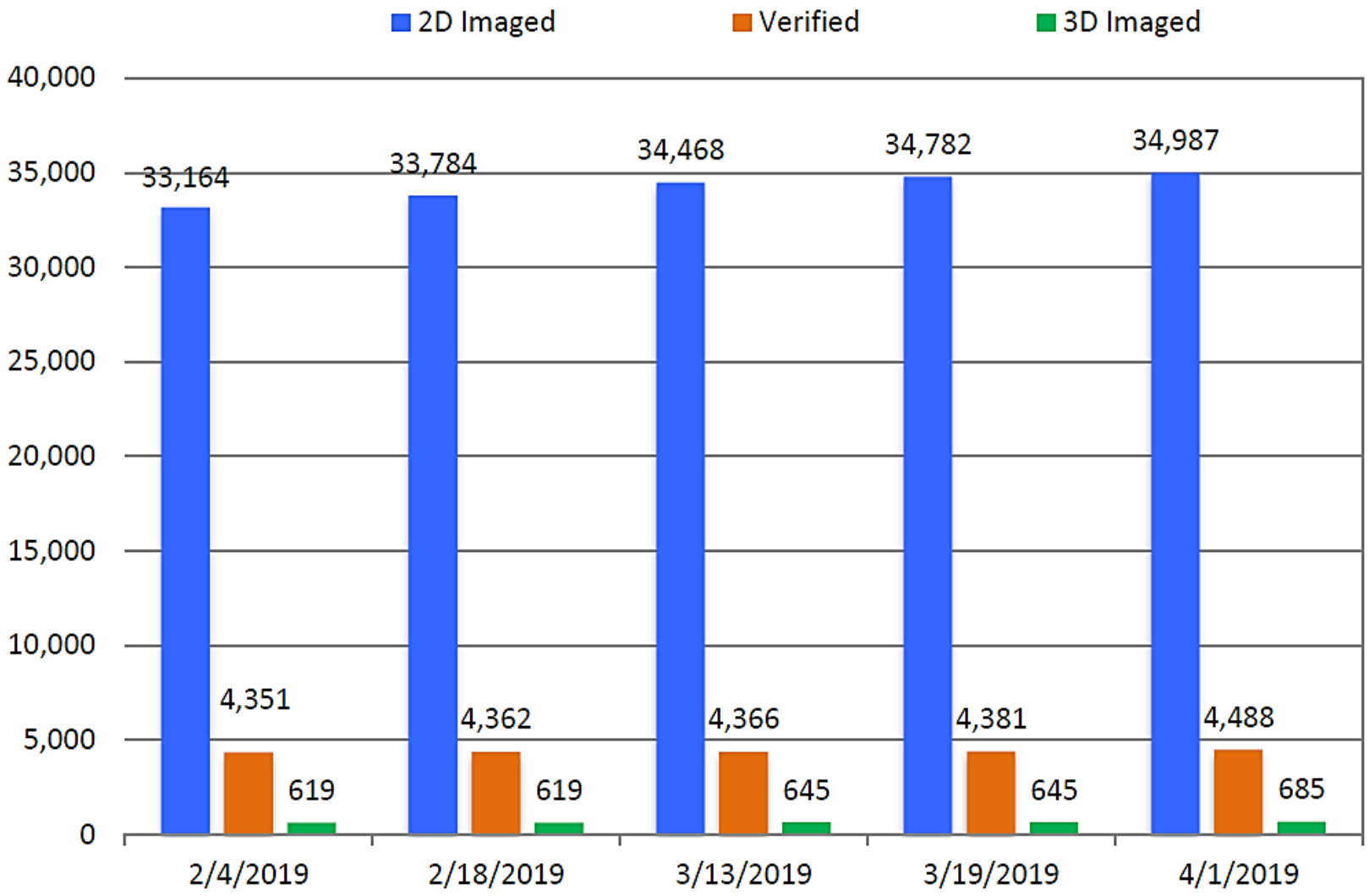
Status-Historical



Status- Recorded/Collected



Status-2D/3D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Verified
3D Imaged
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4,381
645
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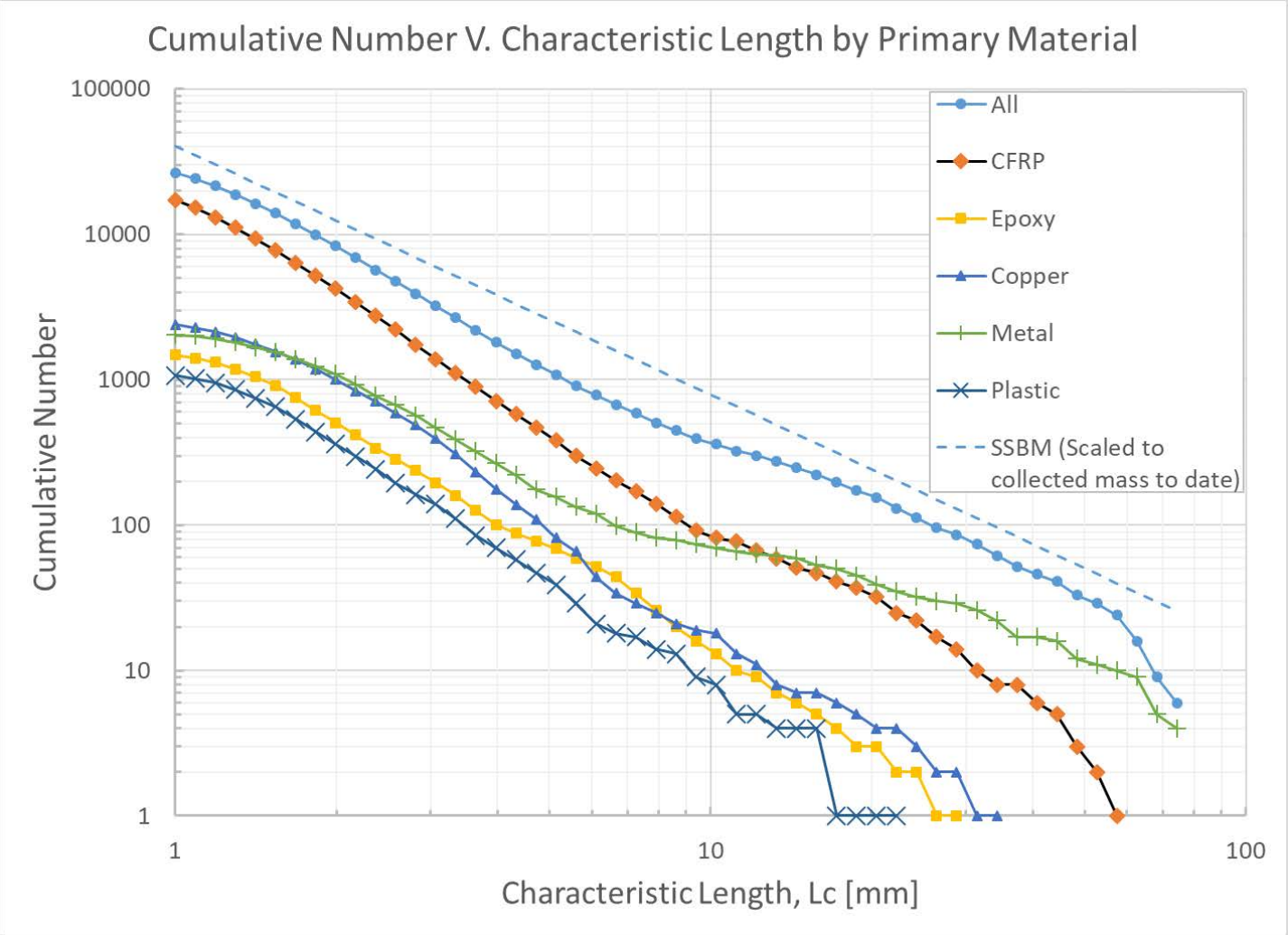
2/4/2019
2/18/2019
3/13/2019
3/19/2019
4/1/2019

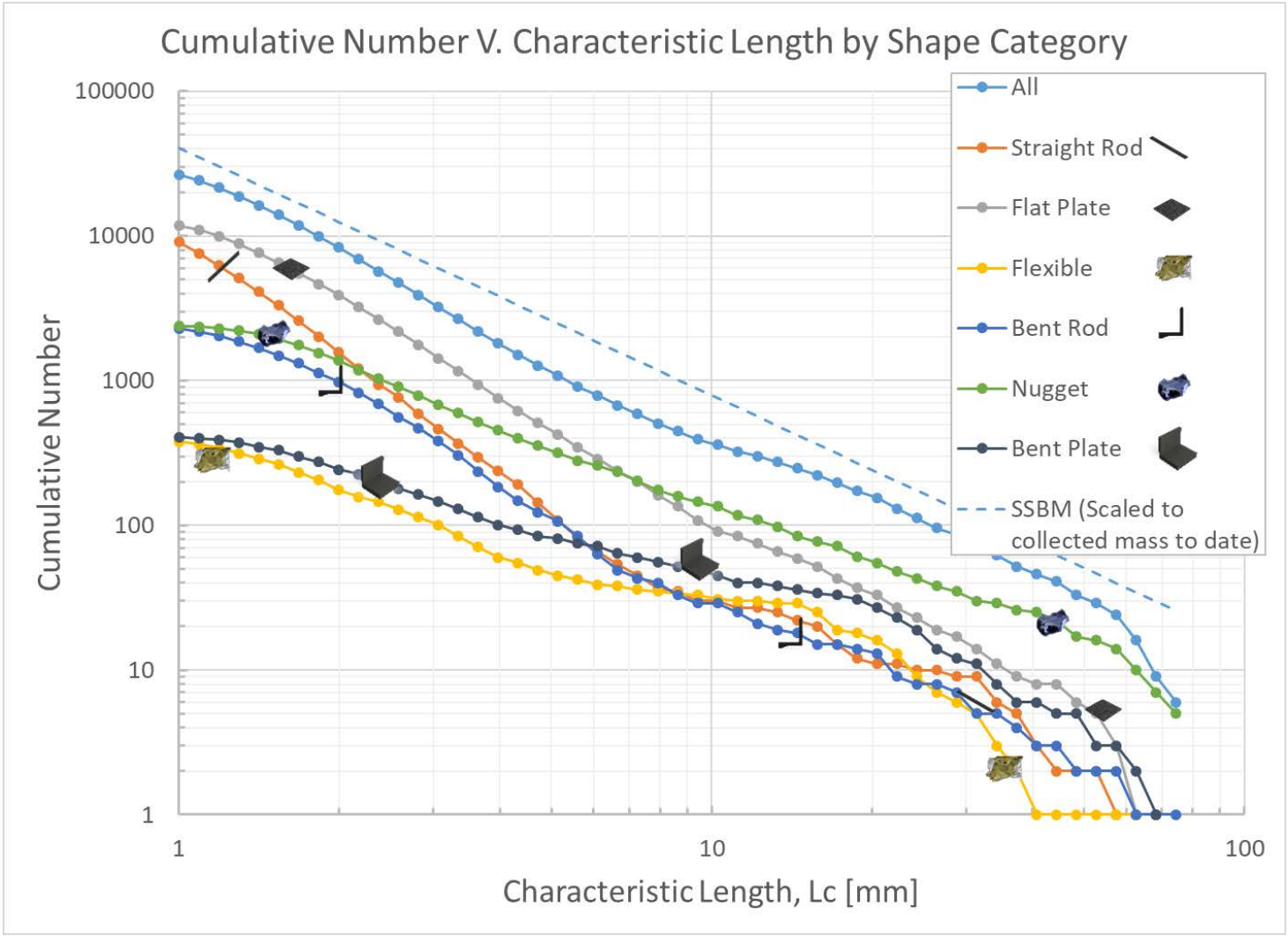
Status- Size

as of 01/23/2019



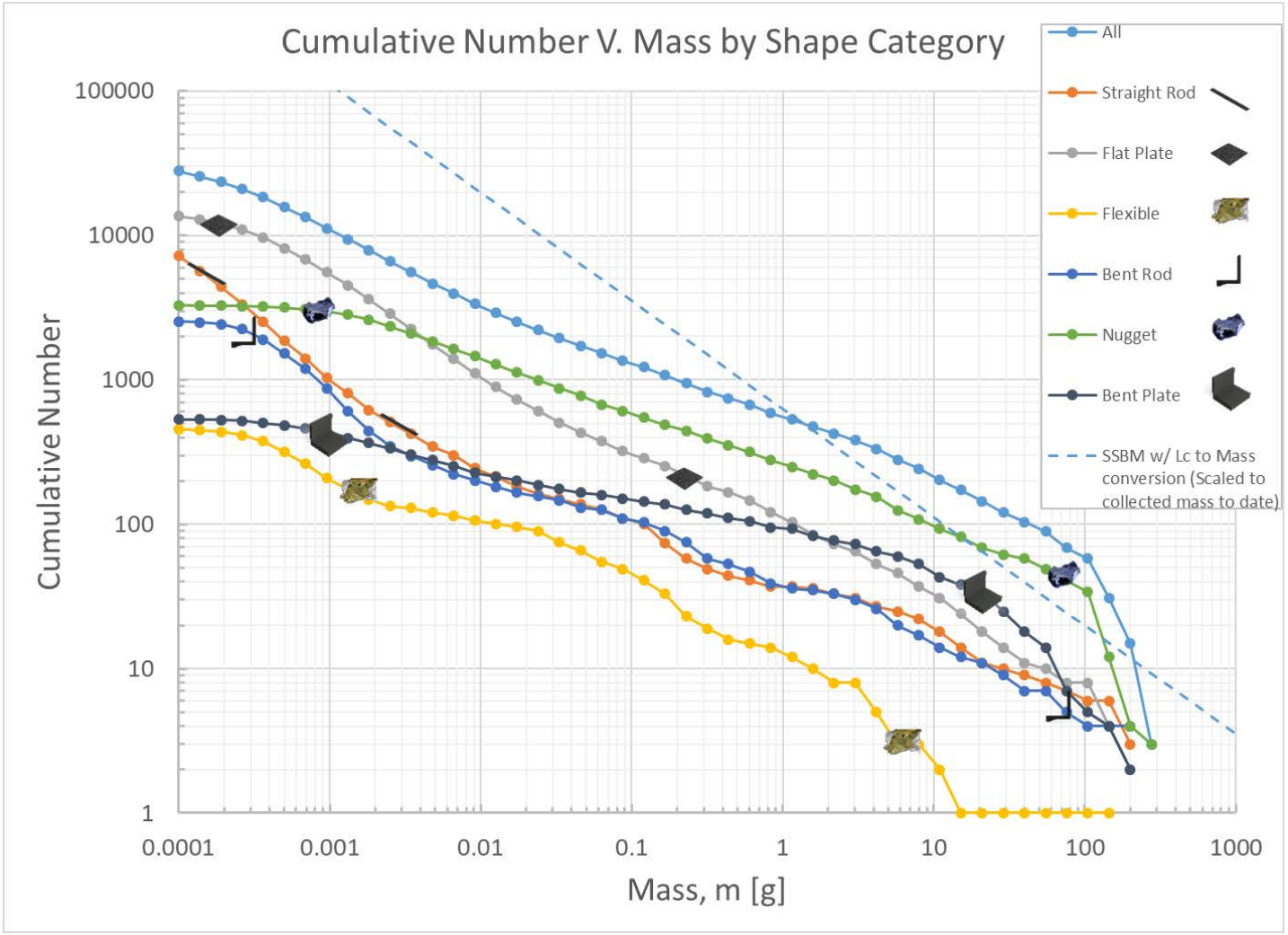
Status-Shape as function of L_c

as of 01/23/2019



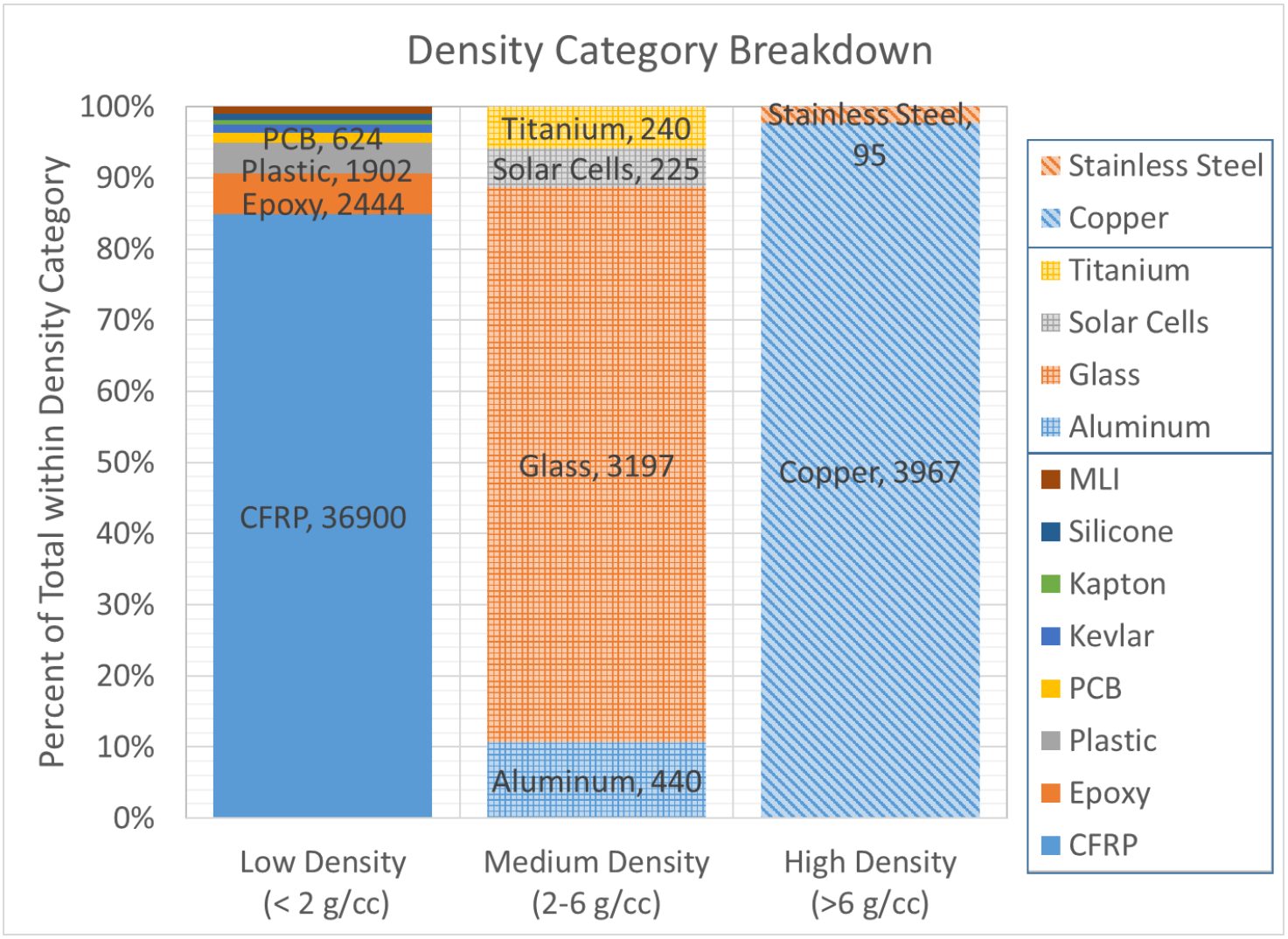
Status-Shape as function of Mass

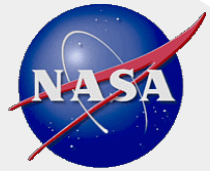
as of 01/23/2019



Status-Density

as of 01/23/2019





Plan Forward-

Prepping for Next Measurements

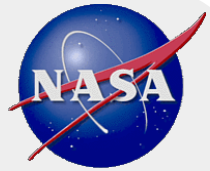
Next steps- near term

- **On-going research focus**
  - Current data is heavily biased towards CFRP, focus on larger fragments
  - Using X-ray imagery to extract number of fragments in intact soft catch panels
  - Mass all 3D fragments
  - Collect subset of fragments to collect laboratory-based optical measurements and radar measurements to compare optical inferred sizes and radar cross sections
  - Data will be used in the development of ORDEM 4.0

- **Continue investigating non-spherical projectiles with various densities improve damage equations**
  - HVI test program, in support of the Orbital Debris Progam Office (ODPO), is investigating the damage characteristics of non-spherical particle impacts into US lab type whipple shields.
  - Projectile = Al 2024-T3 non-spherical projectiles; Velocity = 7 km/s; Impact angle = 0°

Thank you

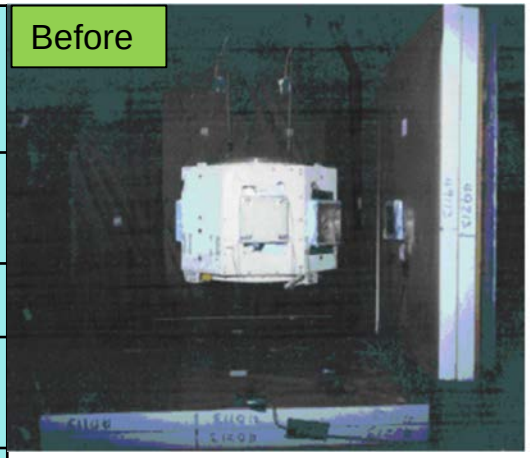
Back-Up



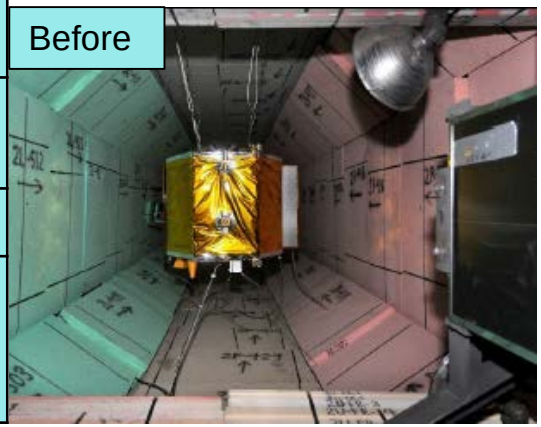
Previous Laboratory Impact Test SOCIT vs DebriSat

	SOCIT U.S. Navy Transit 1960's era satellite	**DebriSat** Representative modern spacecraft in LEO
Target body dimensions	46 cm (dia)×30 cm (ht)	60 cm (dia)×50 cm (ht)
Target mass	34.5 kg	56 kg
MLI and solar panel	No	Yes
Projectile material	Al sphere	Hollow Al cylinder with attached nylon bore-rider
Projectile dimension/mass	4.7 cm diameter, 150 g	8.6 cm × 9 cm, 570 g
Impact speed	6.1 km/sec	6.8 km/sec
Impact Energy to Target Mass ratio (EMR)	81 J/g (2.8 MJ total)	235 J/g (13.2 MJ total)

Before

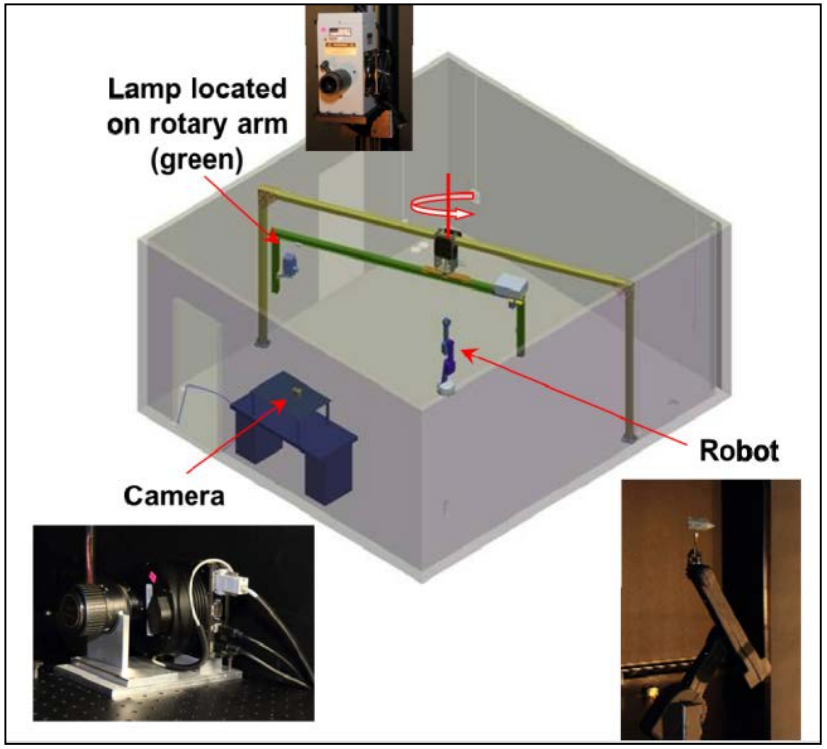


Before



See Ausay, E., "A Comparison of the SOCIT and DebriSat Experiments"

Optical Laboratory Data Analyses: Optical Measurement Center (NASA/JSC)



- ***ASD field spectrometer:*** high-resolution reflectance spectrometer .
- ***SBIG CCD camera and attached filter wheel***, which uses Johnson/Bessell BVRI and SDSS *g'r'i'z'*
- ***75 W Xenon arc lamp***
- ***R17 robotic arm (5 DOF)***
- ***Rotary arm with potentiometer***

- Goal: develop optical size estimation model eliminating need for assumptions in current calculations

$$d = \frac{2 \cdot R}{[\pi \cdot A_g \cdot \Psi(\alpha)]^{0.5}} \cdot 10^{\left[\frac{Mabs(v)+Msun(v)}{-5.0}\right]}$$

R: 36,000 Km

A_g: geometrical albedo=0.175

Ψ (α), Lambertian Phase Function

- Acquire empirical-based bidirectional reflectance distribution function measurements to eliminate need to have aspect angle dependencies
- Upgraded robotic arm with 6 DOF is now underway; expected completion by end of FY18

Radar Facility Data Analyses

Historical:

- 1990s physical measurements acquired (L_c, area, and mass)
- Majority of objects investigated were aluminum or steel
- Radar measurements were taken at multiple angles in order to avoid undersampling the RCS aspect angle variations
- Data were taken at a wide range of frequencies from 2.4 to 18 GHz (S, C, X and Ku bands)

Plan Forward:

- Repeat the 1990s experiment with more modern materials, a large frequency sweep, and collect RCS measurements in various aspect angles – *radar facilities are currently being assessed for cost, resources, and availability*
- Similar to previous analysis, the physical parameters will be compared with RCS measurements to investigate the relationships for a broader subset of materials/shapes
- The DebriSat fragments will provide the opportunity to compare optical measurements against optical inferred sizes and radar cross sections