# OSIRIS-REx: Engineering Challenges of Sampling an Asteroid

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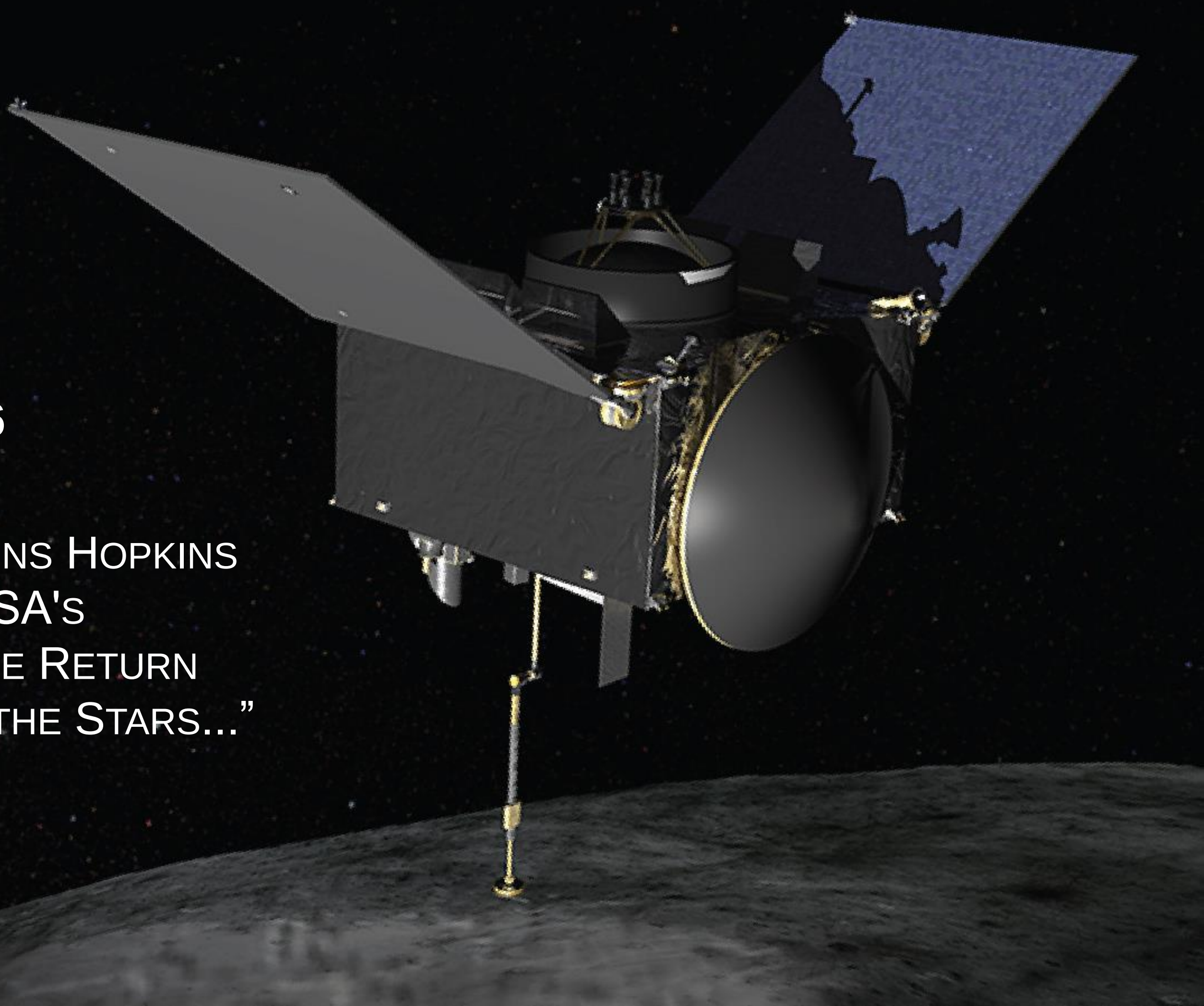
October 17, 2016

Presented at Johns Hopkins University, "NASA's Asteroid Sample Return Mission - Meet the Stars..."



# LAUNCH! SEPTEMBER 8, 2016

- Launch highlights: https://www.youtube.com/watch?v=AG1pE90ue5w&feature=youtu.be
- Launch Video: https://youtu.be/ULfQdFY9PQM

# Flight System Facts

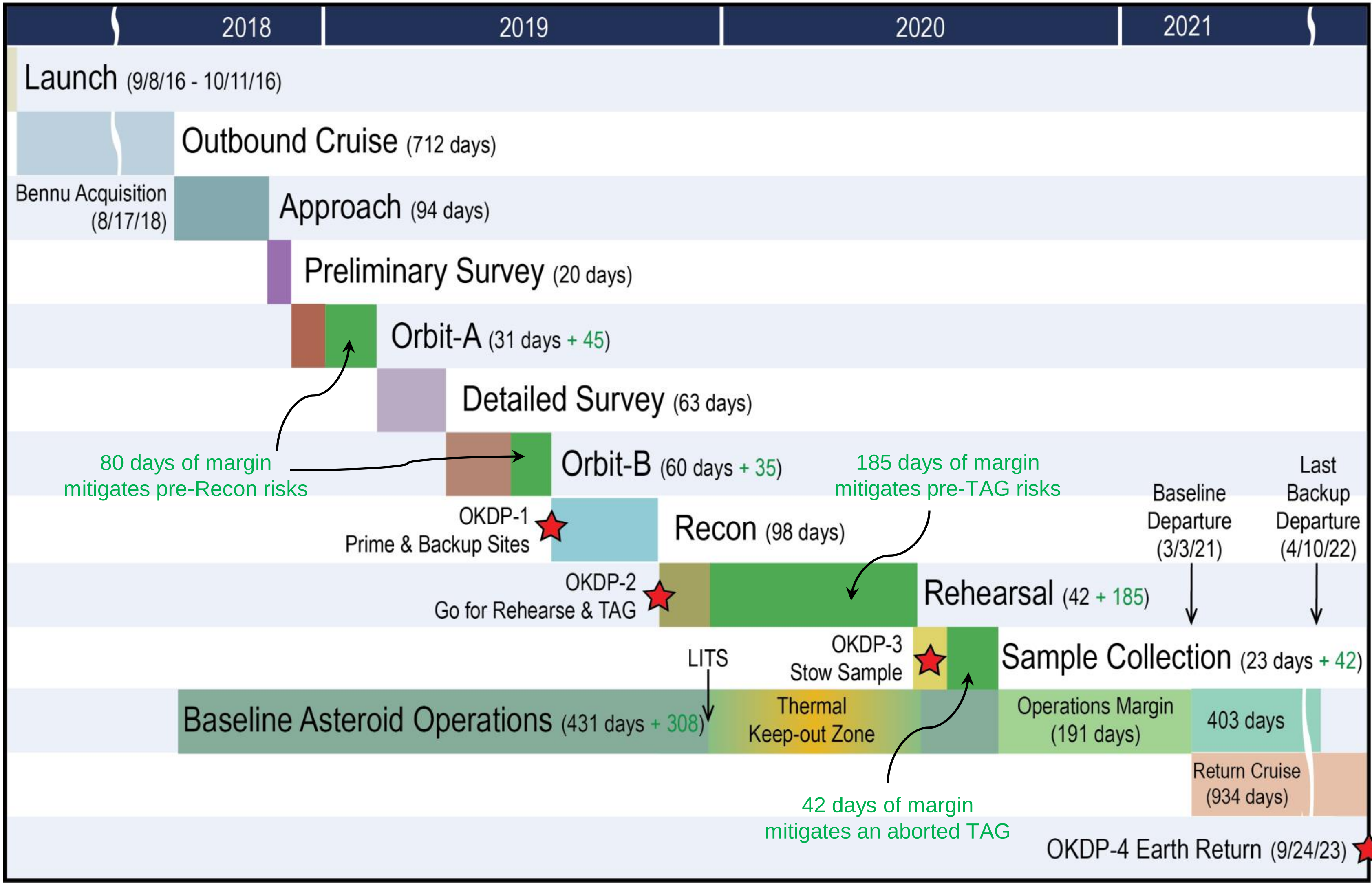
- 2104 kg (4639 lbs), half is fuel!
- 2 meters (6.6 feet) per side
- 1200 W
- 8.5 m$^2$ (91 square feet) of solar panels
- Lithium ion batteries
- 5 Instruments:
  - Measurements in x-ray, visible and infrared
  - Laser measurements
- Touch-and-Go Sampler
- Sample Return Capsule

*It's based on other planetary missions (MAVEN, Juno, MRO)*

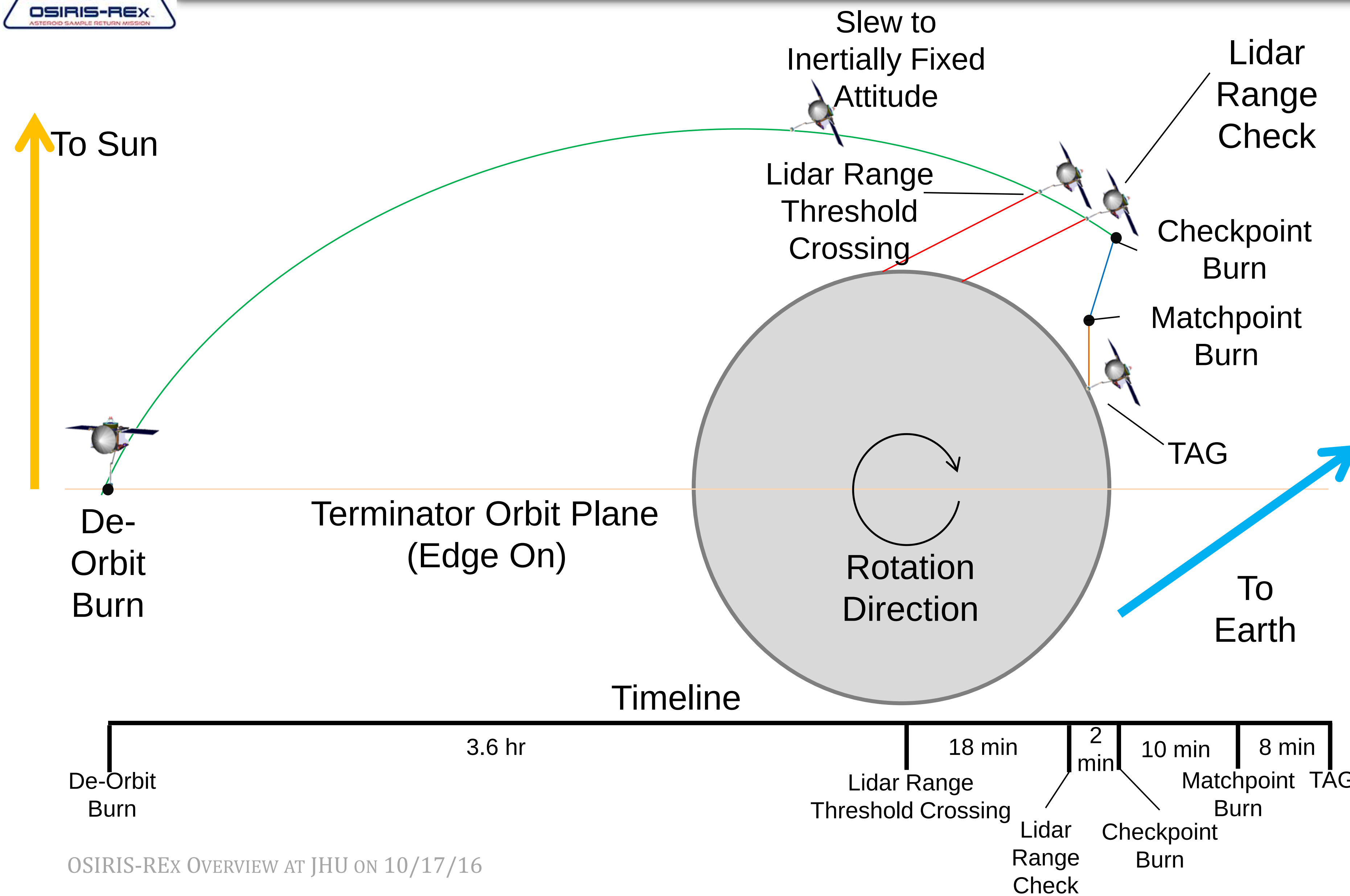
# Exploration of the Unknown

- OSIRIS-REx must retrieve sample from an asteroid that has never been seen up close
- Design Reference Mission provides the step-by-step plan to build our knowledge
  - Created and maintained by project systems engineering team
  - Touches all aspects of the mission design
  - Drives mission architecture and requirements
- Design Reference Asteroid documents what we do know about Bennu and how well we know it (uncertainties)
  - Created and maintained by the science team
  - Based on many observations (Arecibo, Herschel, HST, Magellan 6.5-m, SOAR 4-m, Spitzer, TNG 3.6-m, VATT 1.8-m, VLT 8.4-m, WHT 4.2-m and Kuiper 1.5-m) as well as analysis
  - Peer-reviewed information
  - Drives some aspects of environmental requirements document

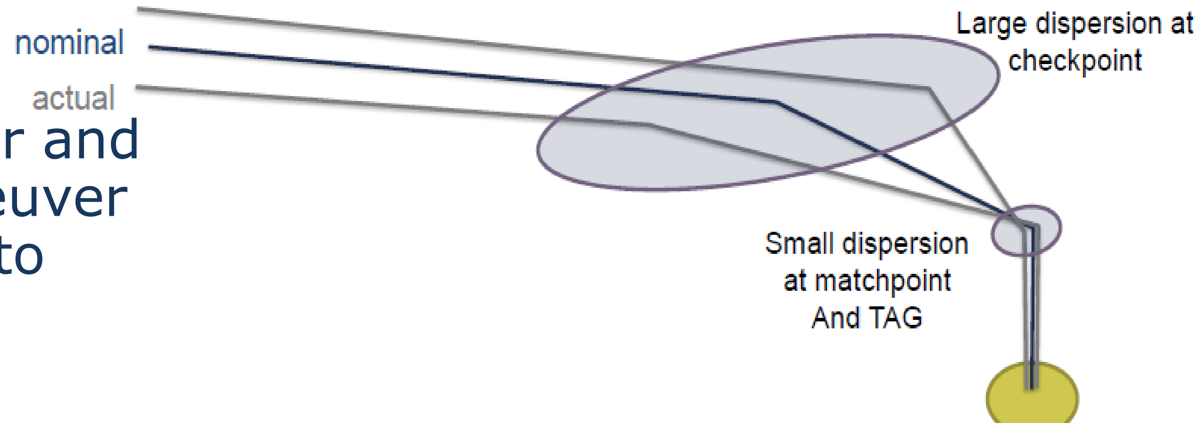
# OPERATIONS TIMELINE



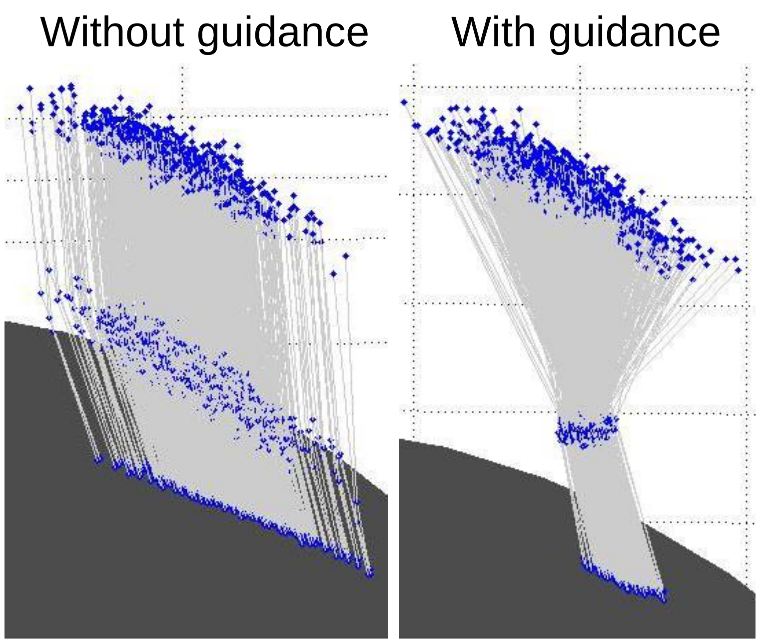
# TAG Operations Concept



# GUIDED TAG APPROACH




- Orbit knowledge error and orbit departure maneuver execution error lead to large dispersion at Checkpoint
- Range threshold and pre-Checkpoint LIDAR measurements allow closed loop corrections to Checkpoint maneuver to achieve original Matchpoint location
- Matchpoint corrected to original TAG approach trajectory



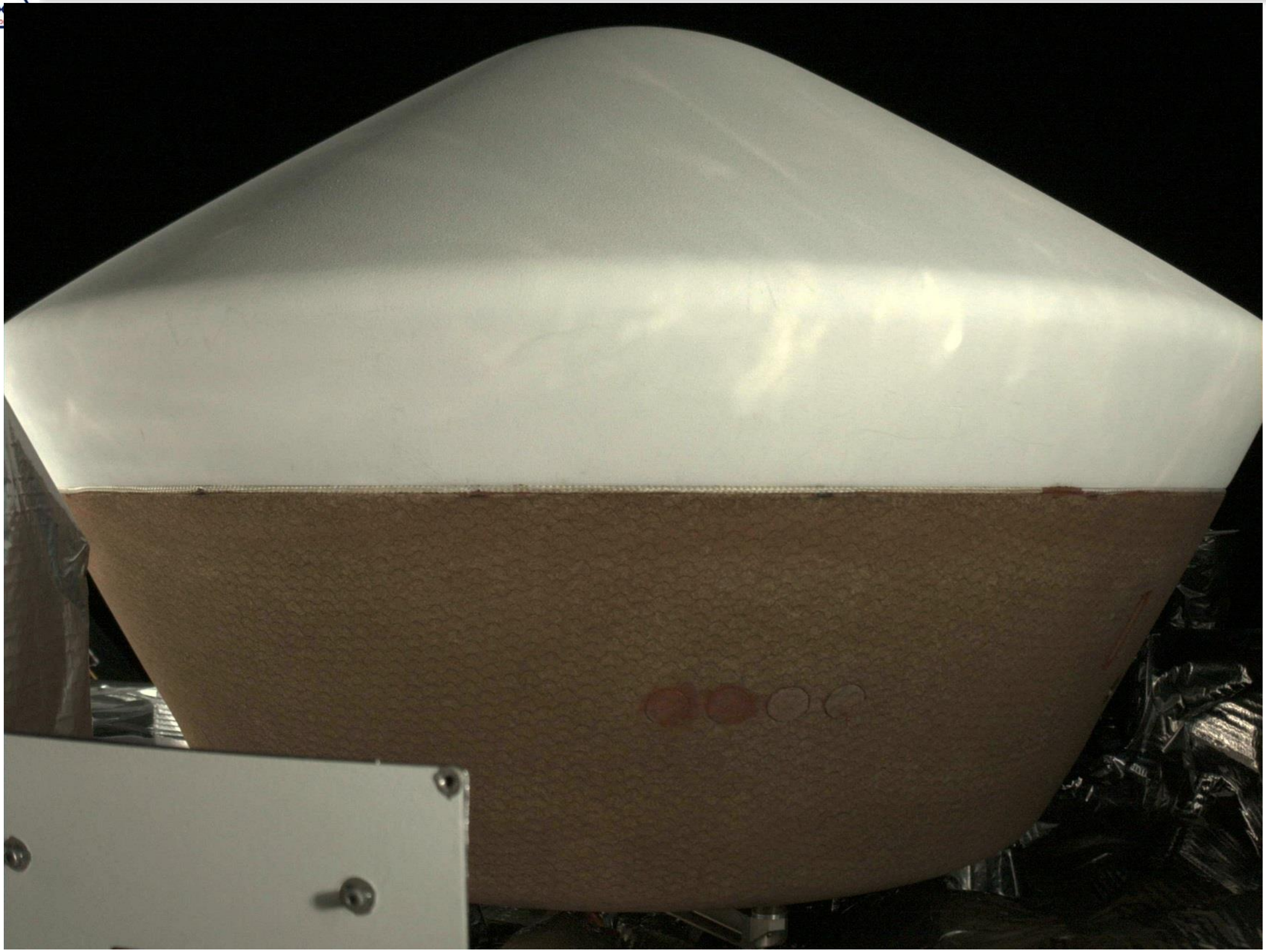
# Design Reference Asteroid

- Orbital Properties
  - Known extremely well, through ground-based astrometry and radar observations in 1999, 2005, and 2011
  - Approach imagery will be easy
- Bulk Properties
  - Size and shape known to within about 10 m
  - Mass and density uncertainty is reasonable for navigation analysis
- Rotational Properties
  - Spin rate known to 0.05%
  - Pole known to within 2 degrees
- Radar Properties
  - Does not drive mission design
- Photometric Properties
  - Drives camera design

# Design Reference Asteroid (cont.)

- Spectroscopic Properties
  - Drives spectrometers
- Thermal Properties
  - Thermal model used for spacecraft thermal analysis
  - Thermal modeling done with engineering feedback to ensure results were useful
    - Engineering tools assume spherical object
- Surface Analog Properties
  - Used for TAG simulations
- Environmental Properties
  - Satellites (stability, size limit, etc.)
  - Dust

# SRC from StowCam, Illuminated by Stray Light



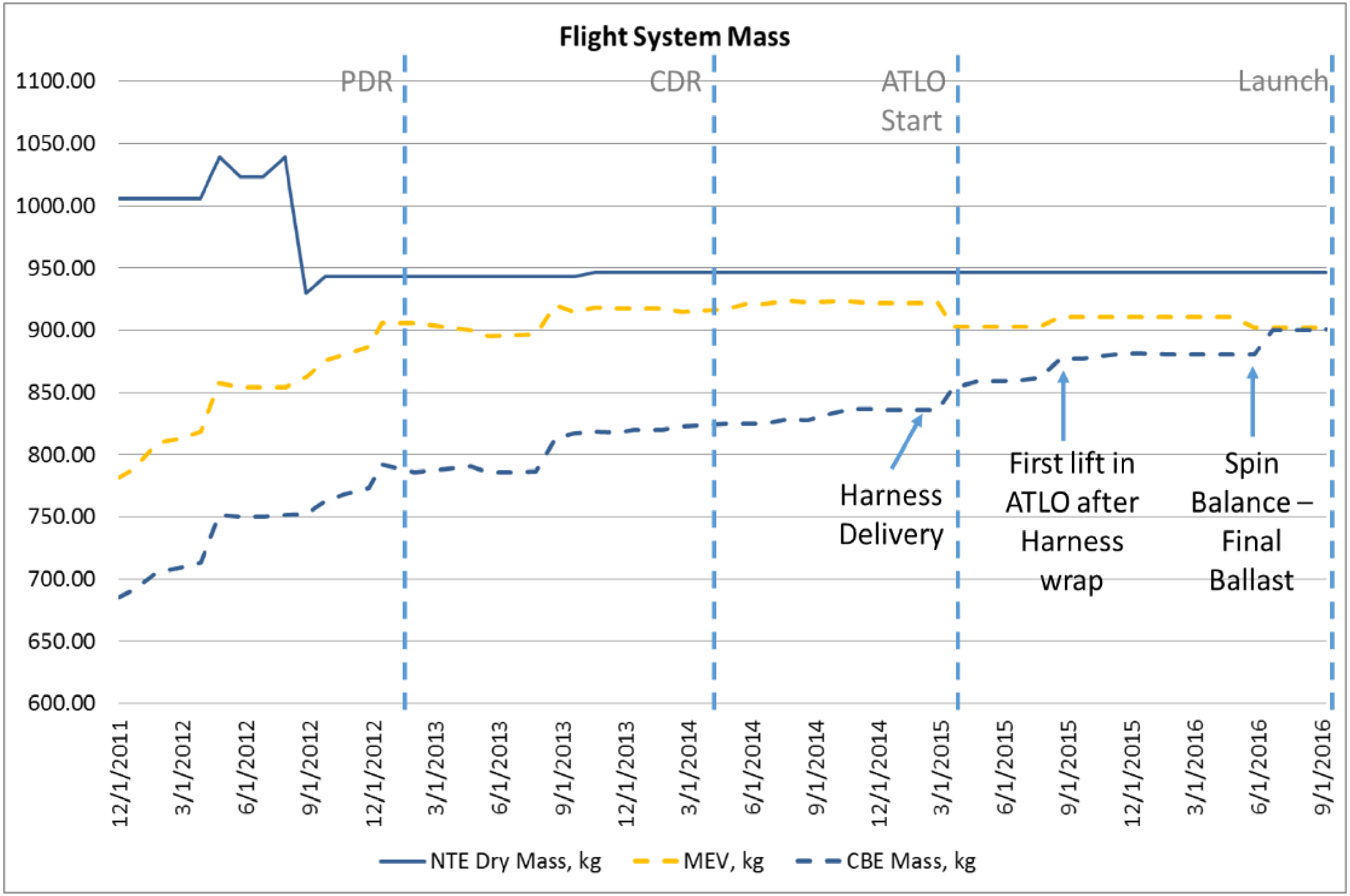
# Sample Return Capsule Nearly Identical to Stardust SRC

- Stardust successfully returned a sample from a comet's tail, but one of the parachute deployment pyros did not fire (the other one did)
- OSIRIS-REx performed some testing which discovered an unexpected shock environment, likely explaining the issue
- Other testing uncovered issues with the parachute cord

- Just because something works once doesn't mean it will work reliably a second time.

- Reliability of spacecraft is outside the experience of every-day life.

# Mass Growth


Flight System Mass
PDR
CDR
ATLO Start
Launch
1100.00
1050.00
1000.00
950.00
900.00
850.00
800.00
750.00
700.00
650.00
600.00
Harness Delivery
First lift in ATLO after Harness wrap
Spin Balance – Final Ballast
12/1/2011
3/1/2012
6/1/2012
9/1/2012
12/1/2012
3/1/2013
6/1/2013
9/1/2013
12/1/2013
3/1/2014
6/1/2014
9/1/2014
12/1/2014
3/1/2015
6/1/2015
9/1/2015
12/1/2015
3/1/2016
6/1/2016
9/1/2016
NTE Dry Mass, kg
MEV, kg
CBE Mass, kg

# THIS JOB IS DIFFICULT!

- Space missions are really hard because:
  - It requires a tremendous amount of energy to get into space—essentially a controlled explosion
  - Once on its way, it would take another launch to get to the spacecraft and fix any hardware problems
  - The level of reliability is beyond everyday experience
  - A single failure can end a mission
- We do these things in space, “not because they are easy, but because they are hard.” --JFK
- My job is fun because it is hard.
- A successful mission is the product of many people and many perspectives