

On-Orbit Results of ISS ROSA (iROSA) and Double Asteroid Redirect Test (DART) ROSA Missions

Space Power Workshop 2023

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Redwire Space Systems - Goleta

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Redwire Space Employs Over 750 Jobs in U.S. and Europe

Redwire Space Provides 50+ Years of Space Flight Heritage and Innovative Capabilities for Civil Space and National Security Missions!



COLORADO (Littleton and Longmont)

- 102,000 sq. ft total in CO
- Clean Rooms
- RF & Antenna Systems
- Deployable and Retractable Space Structures
- Solar Arrays, Batteries, Thermal Products
- Space Systems Engineering Services
- Camera Systems
- Flight Avionics
- Data Recovery Systems
- In-House Testing Capabilities
- Digital Engineering
- Modeling & Simulation

CALIFORNIA

- Collaborating with JPL
- 80,000 sq. ft. office & manufacturing area
- 3-Story High Bay
- Deployables IA&T
- ISS & PPE Large ROSA IA&T
- High Power Solar Array R&D

NEW MEXICO

- 14,000 sq. ft facility
- Operate and Maintain AFRL testing facility
- Design and Analysis Services
- Structural & Thermal Testing
- Launch Accommodation Hardware
- Thermal Control Hardware
- Deployable Technologies

Cleared Personnel

ALABAMA

- Strong partnerships with NASA MSFC

FLORIDA

- **Redwire Corporate Headquarters in Jacksonville**
- 37,247 sq. ft facility
- Clean rooms
- Advanced In-Space Manufacturing Technology
- Large In-Space Manufacturing Project – OSAM-2/Archinaut One
- ISS Payload Development

INDIANA

- 22,000 sq. ft facility
- In-space Research
- ISS Payload Development
- Advanced Space Manufacturing Technology
- Biotechnology, bioprinting, on-orbit manufacturing
- ISS/CASIS

MASSACHUSETTS

- 18,000 sq. ft. facility
- Clean Rooms
- Sun Sensors & Star Trackers
- Integrated Camera Systems
- ADACS Systems
- Satellite Systems

DC/VA/MD

- Engaging NASA GSFC in MD
- 8,000 sq. ft. facility under construction (2/3 SCIF)
- SCIF, Classified Systems Access
- Digital Engineering Lab

Merritt Island, FL (near KSC)

- 2,377 sq. ft. facility
- Strong partnership with NASA KSC
- Prelaunch processing laboratory and support
- Commercial partnership with Tupperware Brands
- In-space plant biology research
- ISS and lunar Payload Development



LUXEMBOURG

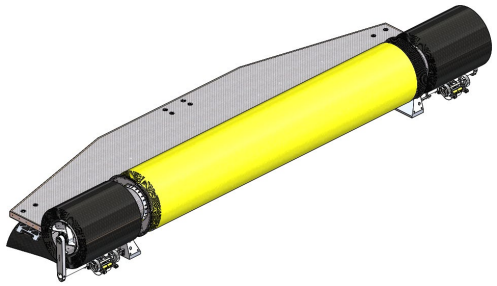
- Redwire Engineering & Sales Center in Europe
- 2,500 sq. ft facility
- Robotic Systems
- Avionics

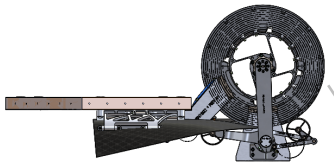
BELGIUM

- QinetiQ Space NV
- 19,000 sq. ft. facility
- Hi-Ref SmallSats, Berthing & Docking Mechanisms, Avionics

Roll-Out Solar Array (ROSA) Nomenclature

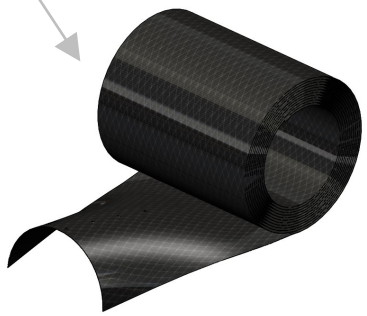
Stowed Wing | **Deployed Wing**





Spacecraft Root or SADA Interface

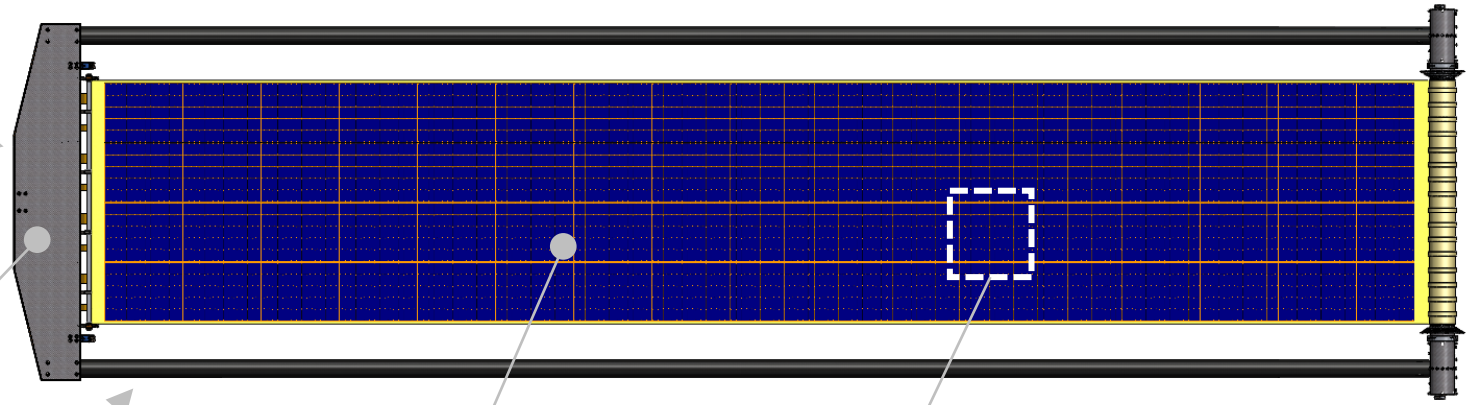
Spacecraft Tie-down Interface



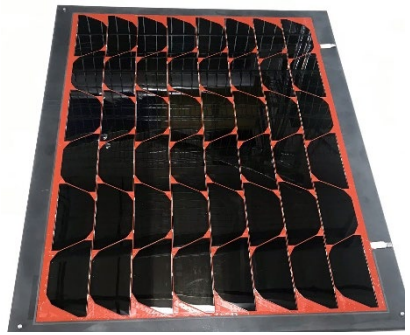
Composite Boom (Stowed)

Offset or Yoke Structure

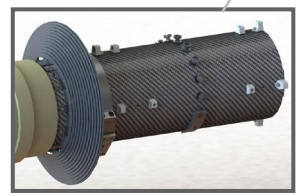
Diode Boards (backside)



Integrated Modular Blanket Assembly (IMBA)



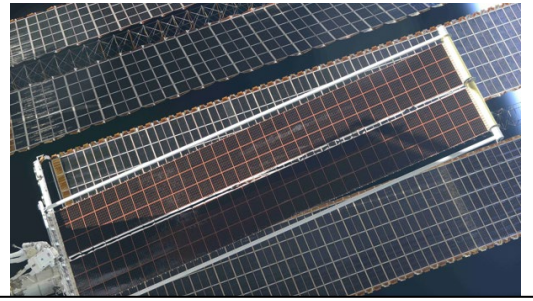
Standard Power Module (SPM)



Mandrel Tube Assembly

ROSA Heritage & Qualification Summary

- International Space Station ROSAs (iROSA) for NASA/Boeing, 28 kW BOL per wing [TRL 9]
  - Wings 1 & 2 deployed in June 2021
  - Wings 3 & 4 deployed in December 2022
  - Wings 5 & 6 delivered and launching in June 2023
- Double Asteroid Redirect Test (DART) ROSA for APL/JHU, 3.4 kW BOL per wing [TRL 9]
  - Two wings were successfully deployed in November 2021
- Ovzon 3 Commercial GEO ROSA for Maxar, 5.3 kW BOL per wing [currently TRL 8]
  - Fully tested and delivered to the customer, launching in 2023
- GEO Qualification ROSA for Maxar, 15+ kW class wing [TRL 7/8]
  - Fully qualified GEO bus ROSA, completed 2020
- ISS ROSA Flight Demonstration (funded by AFRL), 2-3 kW class wing [TRL 7/8]
  - Deployed and retracted on-orbit June 2017



ISS ROSA (iROSA) 28kW Wings
- Deployed Dimensions: 240.4" [6.11 m] wide x 763.6" [19.40 m] long
- Modular IMBA blanket with Spectrolab XTE multijunction solar cells



Maxar 15kW ROSA Qual Wing
- 5.5-in DIA 4-ply booms
- SolAero solar cells



DART 3.3 KW ROSA Wings
- 91.4" [2.3 m] wide x 337.5" [8.57 m] long
- SolAero cells



OVZON 3.8 Kw ROSA Wings
- 105.18" [2.67 m] wide x 494.55" [12.56 m] long
- SolAero cells

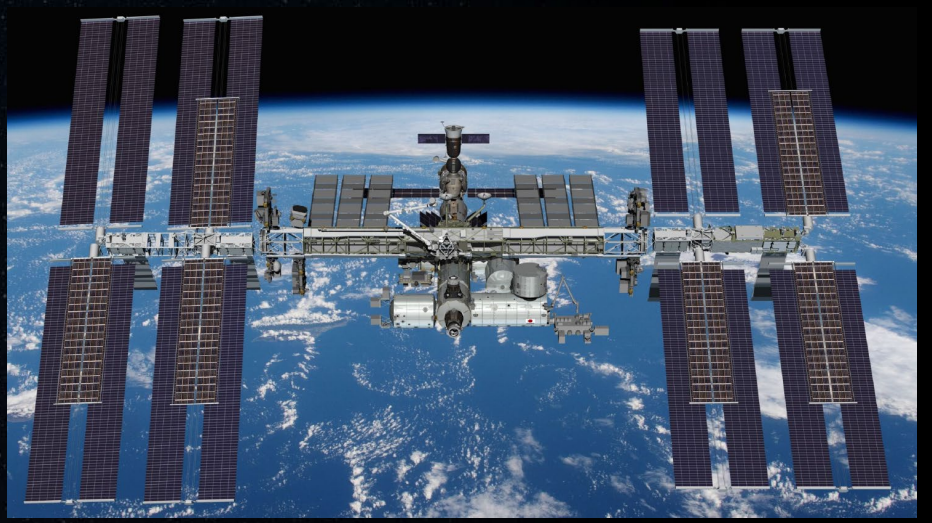


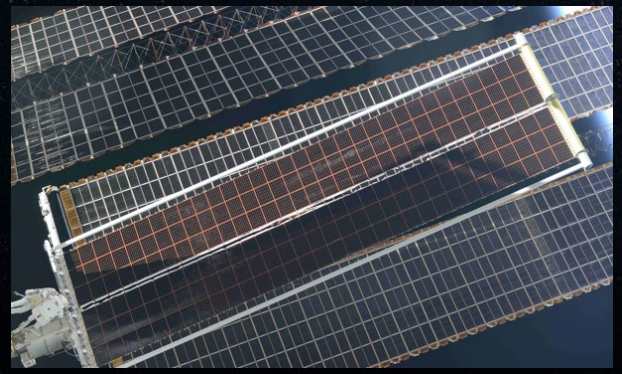
ISS ROSA Flight Demonstration
- 66.4" [1.69 m] wide x 211.0" [5.36 m] long
- Spectrolab & SolAero cells

ISS Power Augmentation Program Overview

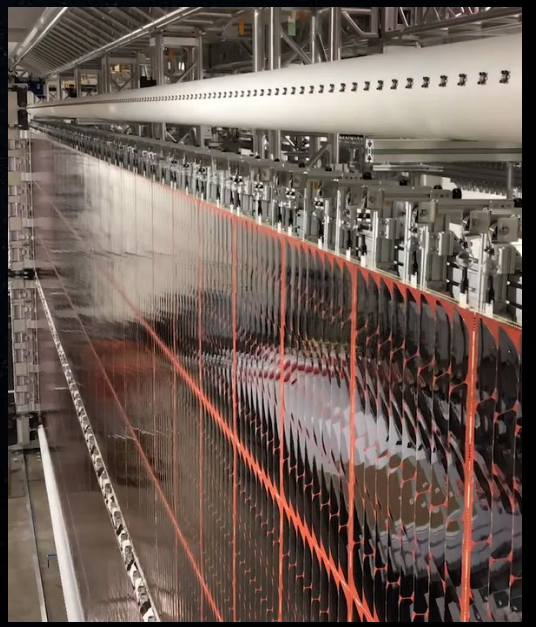
Powering ISS for the next decade and beyond

- Six new ROSA Solar Arrays designed for ISS, called iROSA, provided by Redwire
  - Flight Support Equipment (FSE) and Mast Canister Modification hardware (Mod Kit) provided by Boeing
- Pairs of iROSA wings delivered to ISS via three SpaceX Dragon CRS missions
- Wings installed and deployed by EVA







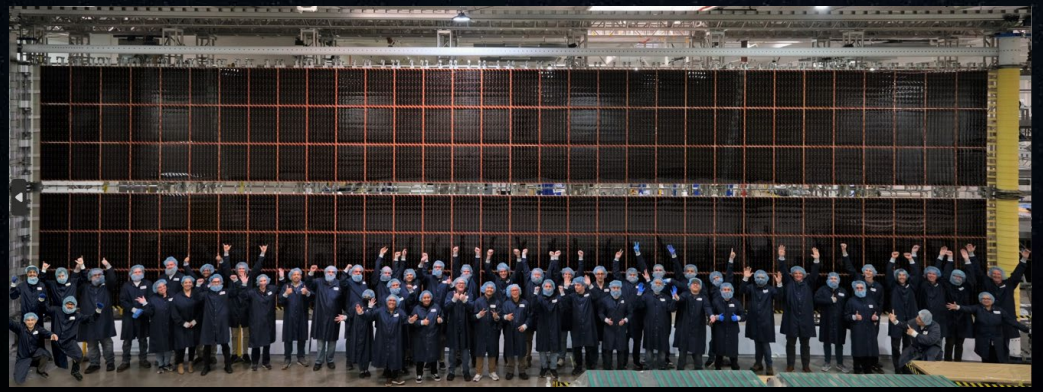


iROSA Solar Arrays

- **Features:**
  - Folded Mandrel ROSA design – Maximized Stowed Volume
  - 6.5” Diameter Boom – Massive Torque Margin
  - 28 kW BOL Flex Blanket featuring Spectrolab XTJ Cells
  - Designed for complete EVA operation
- **Wings 1 & 2 successfully deployed in June 2021**
- **Wings 3 & 4 successfully deployed in December 2022**
- **Wings 5 & 6 delivered and launching June 2023**







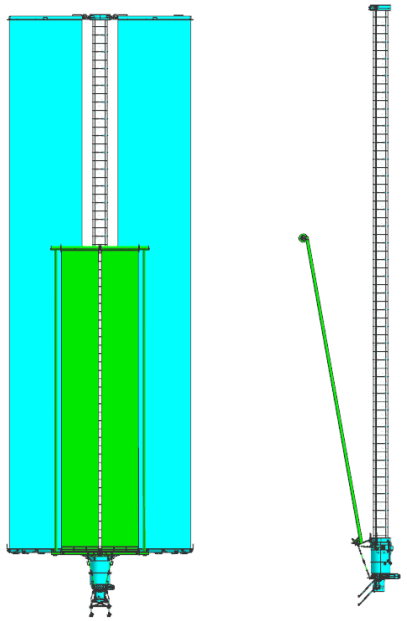


iROSA On-Orbit Performance

- **Deployment durations consistent for all four wings (within 5%)**
  - Ground deployment average from 7:30 (ambient) to 12:30 (cold)
  - Deployment speeds consistent with post-eclipse predictions

Wing #	EVA	Channel	Date	T+ Eclipse	Deploy Time
Wing 1	US EVA 75	2B	6/20/2022	0:08:23	0:09:43
Wing 2	US EVA 76	4B	6/25/2022	0:03:49	0:09:51
Wing 3	US EVA 82	3A	12/3/2022	0:01:37	0:09:28
Wing 4	US EVA 83	4A	12/22/2022	0:03:58	0:10:24

- **Power Production:**
  - 100% of iROSA strings performing as-expected
  - Total channel power is aggregate of legacy arrays (partially shadowed) and new iROSA arrays (canted at 10°)

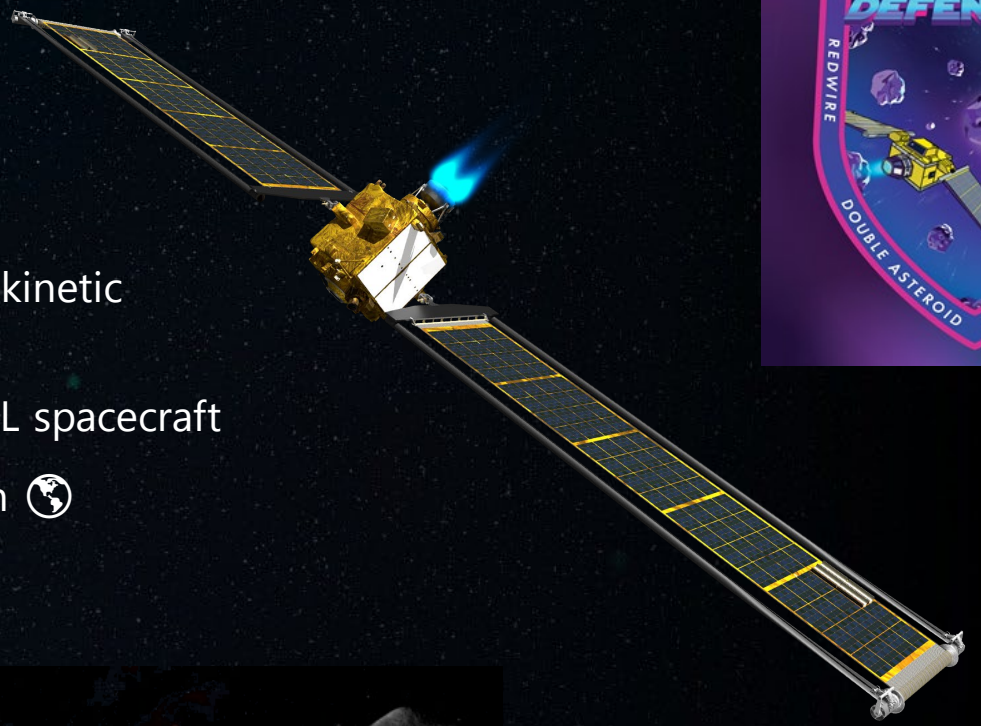


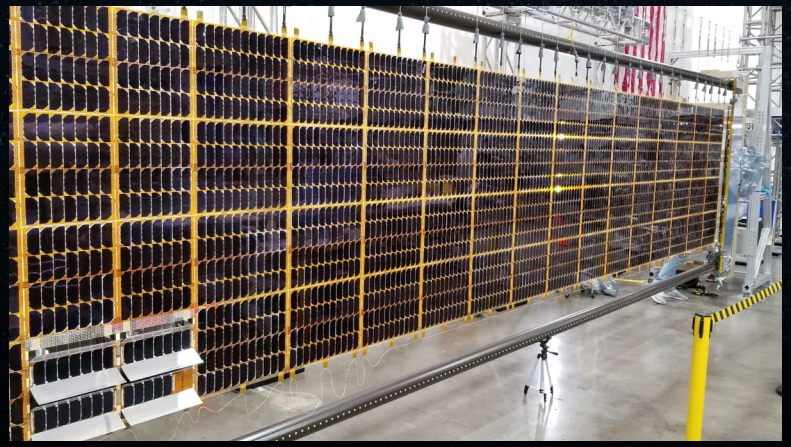
Measured Power of Combined Legacy and iROSA Wings under Operating Conditions			
Channel	**Before kW**	**After kW**	**Delta kW**
2B	17	26	9
4B	18	26	8
4A	21	28	7
3A	19	28	9
		Total:	33

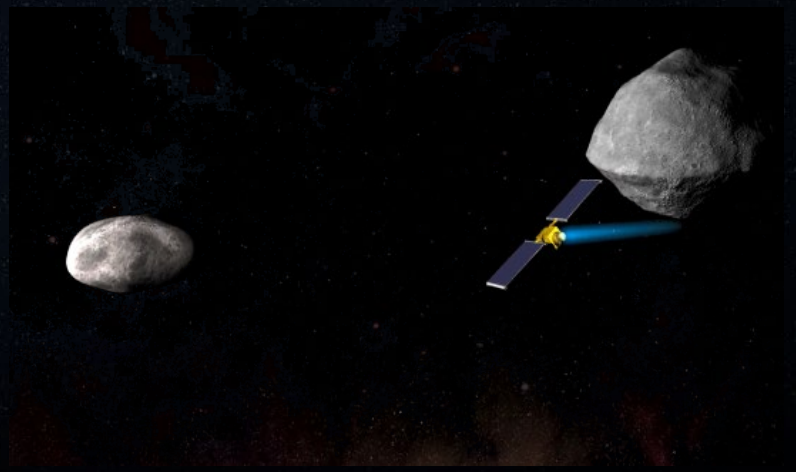
DART Mission Overview

NASA Double Asteroid Redirect Test (DART) Mission

- First-ever spacecraft to demonstrate asteroid deflection by kinetic impactor on asteroid target
- Redwire delivered two 3.3 kW BOL ROSA arrays for JHU/APL spacecraft
  - 🌎 Designed and built by Redwire's Planetary Defense Team 🌎
- Both arrays successfully deployed in November 2021!



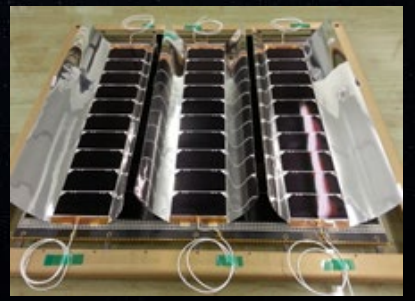


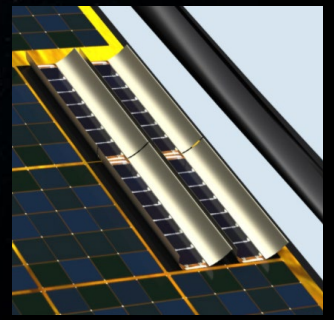


DART ROSA Summary

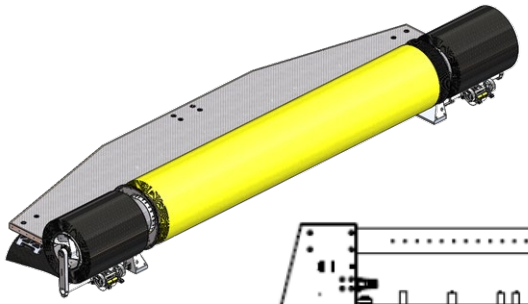
- **Key Requirements:**
  - Power: > 6.6 kW Total (3.3 per Wing)
  - Mass: > 100 W/kg
  - Stiffness: > 0.25 Hz Deployed and > 50 Hz Stowed
- **Two segments using SolAero ZTJ 30.5 cm² CICs:**
  - Main Bus Segment (60 V) – QTY 14 4x7 CIC SPM
  - NEXT-C Ion Segment (100V) - QTY 56 4x11 CIC SPM
- **Transformational Solar Array (TA) Experiment:**
  - Two SPMs used Redwire's FACT Concentrators with SolAero IMM CICs to evaluate performance for future extreme missions

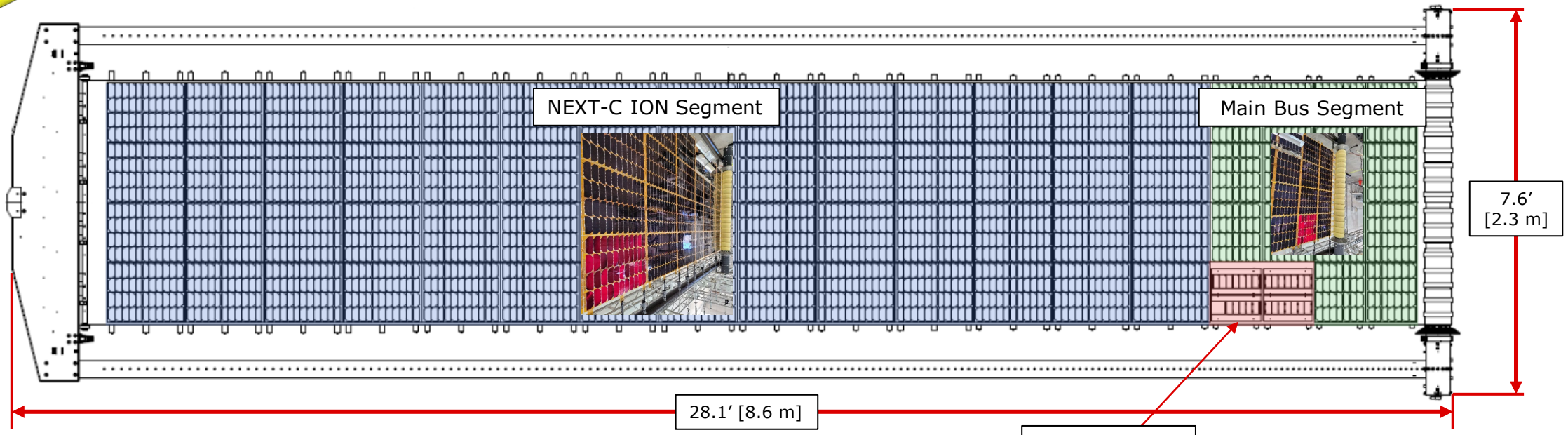






DART Power Segment Layout

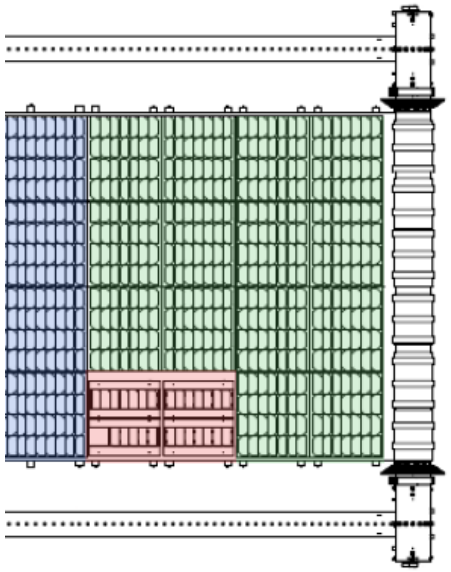


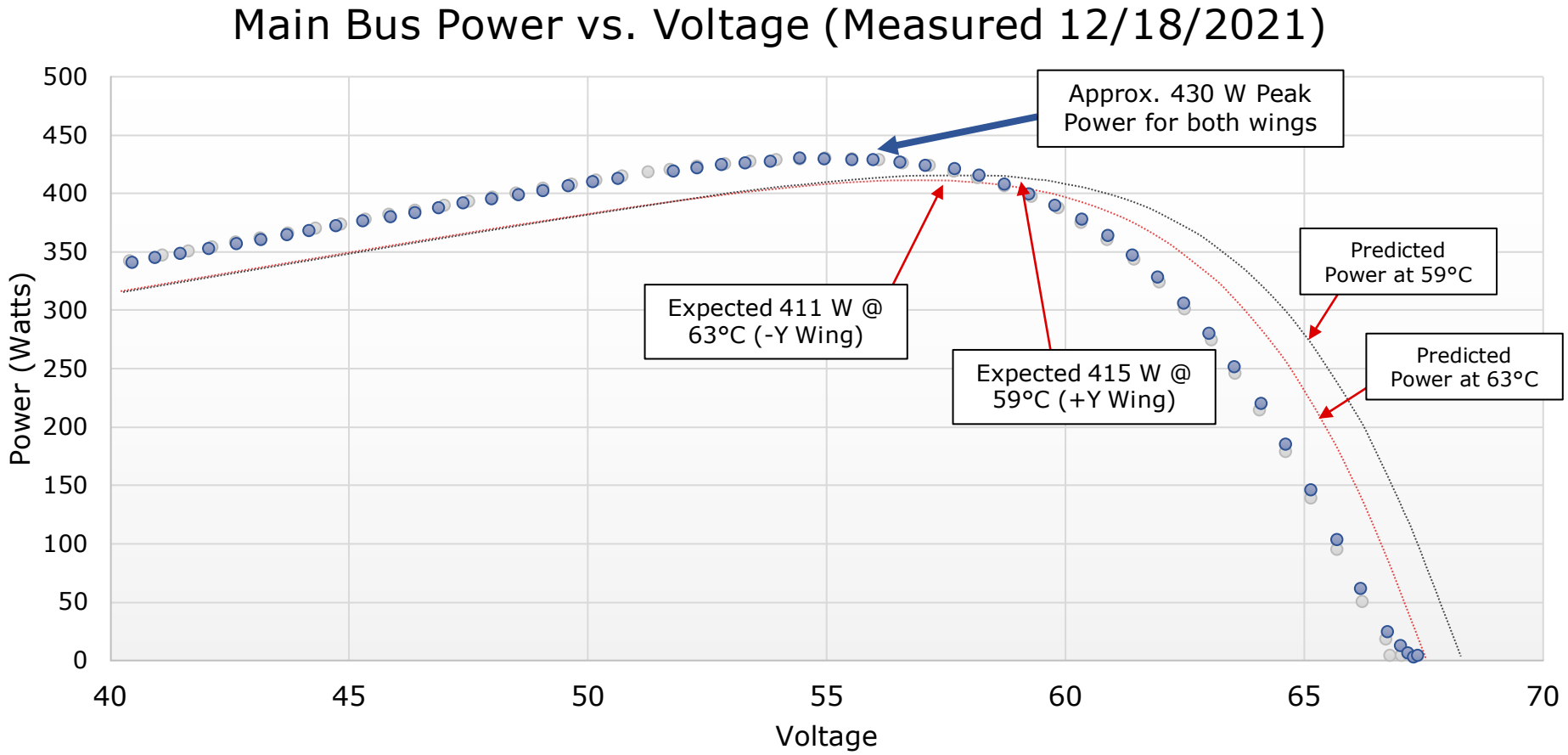


DART On-Orbit Results

- **Deployment Results:**
  - Both ROSAs deployed within nominal deployment time
- **Power Results:**
  - Power measured for all segments during initial ROSA deployment on 11/24/21
  - I-V Sweep performed on Main Bus and TA segments on 12/18/2021
    - Due to NEXT-C anomaly, no additional sweeps were measured
  - Results:
    - Main Bus Segments performed as expected for entire mission
    - Ion Segment also produced power as expected, but only operated for short duration prior to ion thruster issues

DART Main Bus Power Measurement

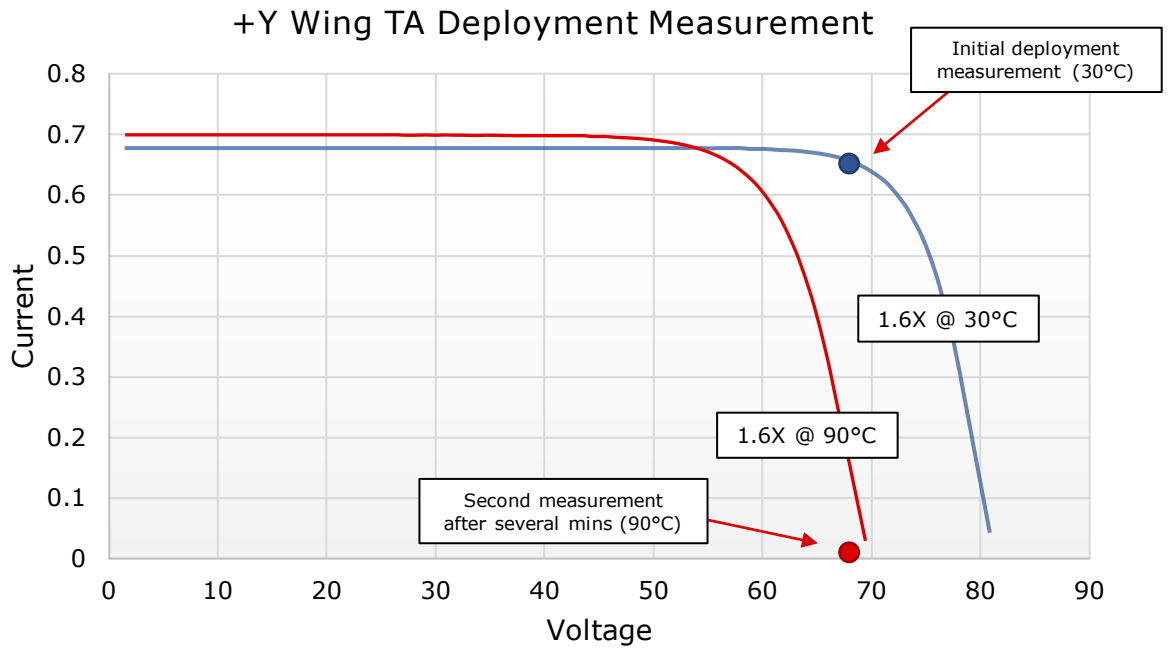




Wing likely operating hotter than temperature sensor measurements (sensors located on backside)

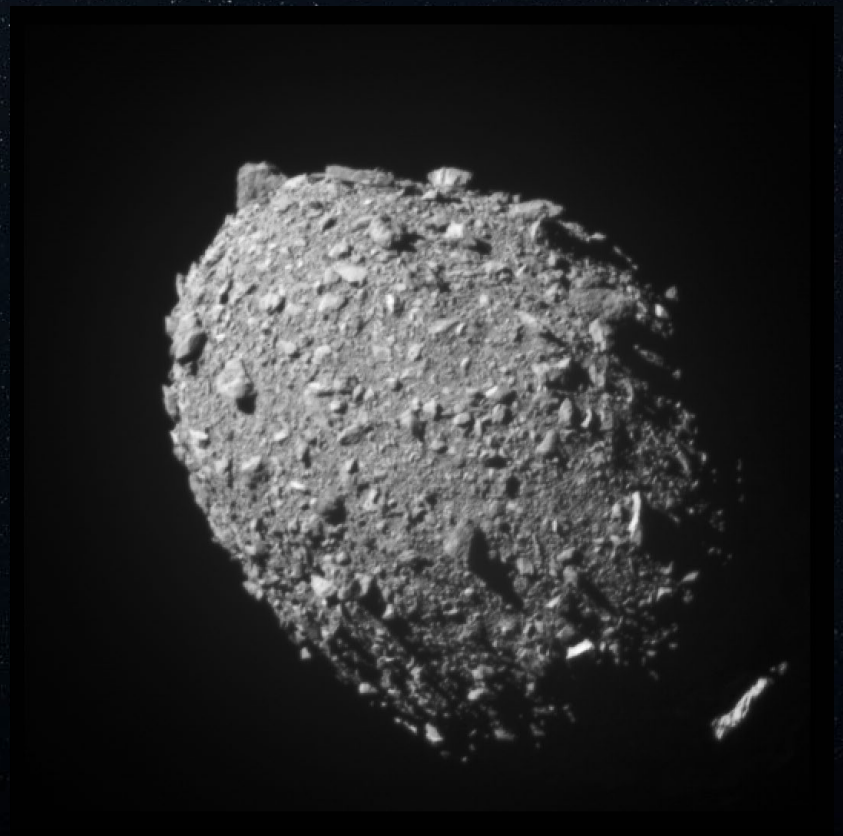
DART TA Results

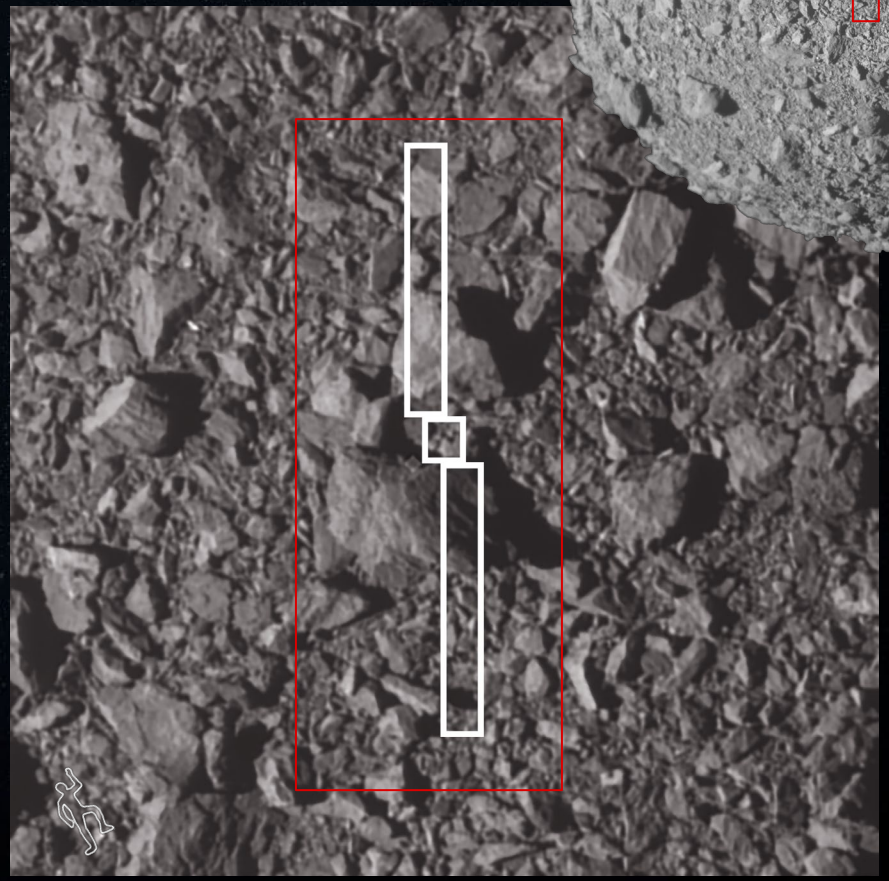
- **Experiment results inconclusive**
- **What we know:**
  - FACT concentrators deployed
    - Approx. 1.6X concentration predicted (rough sun-pointing at deployment)
  - Voltage as expected at deployment
  - I-V sweep after 24-day OC showed lower than expected voltage
    - Unable to perform additional I-V sweeps due to NEXT-C issues

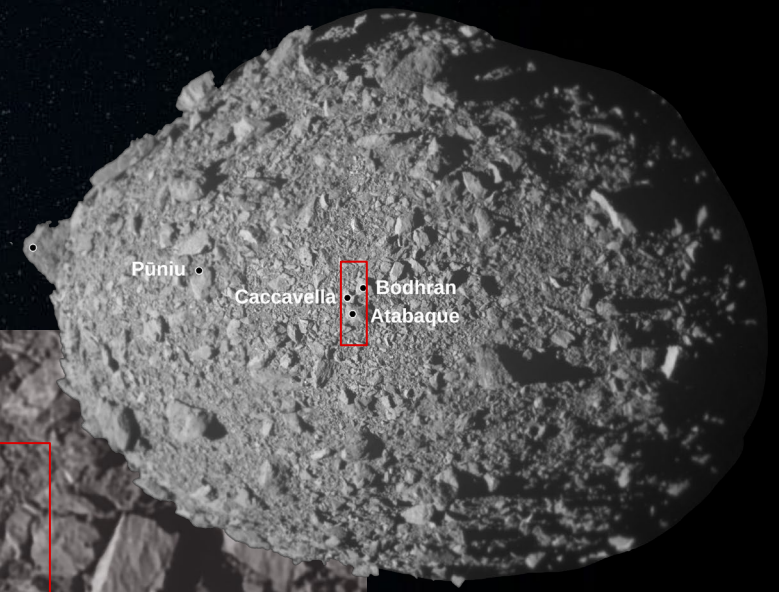


DART Ending-of-Life

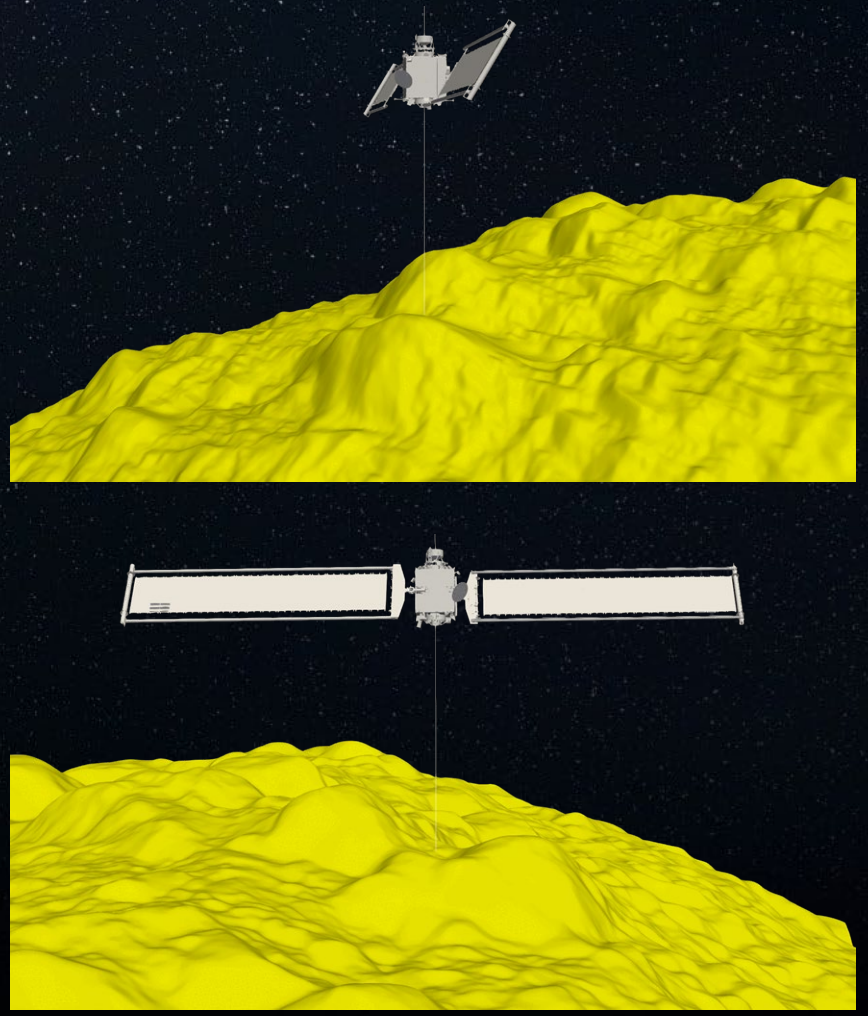
DART spacecraft impacted Dimorphos at 6.6 km/s on September 26, 2022

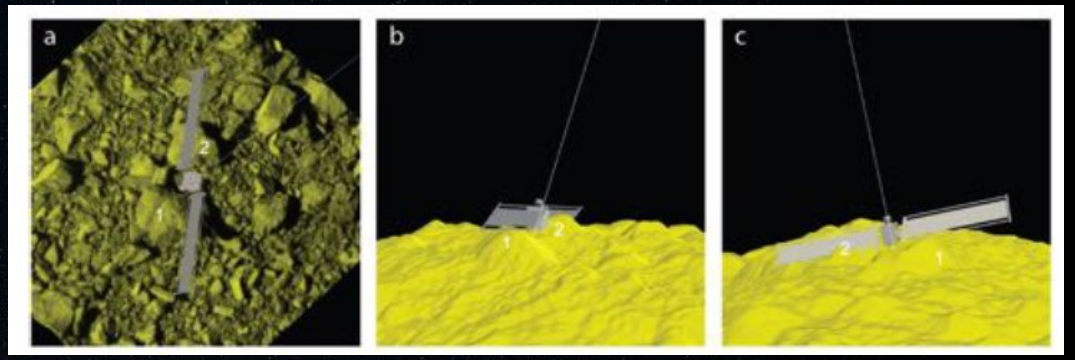


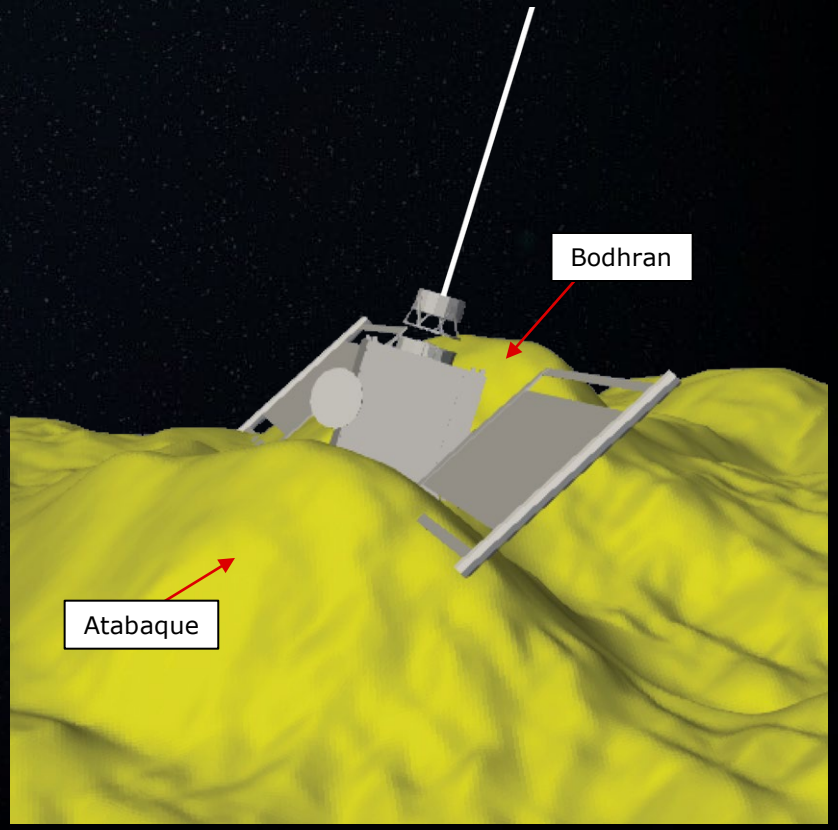




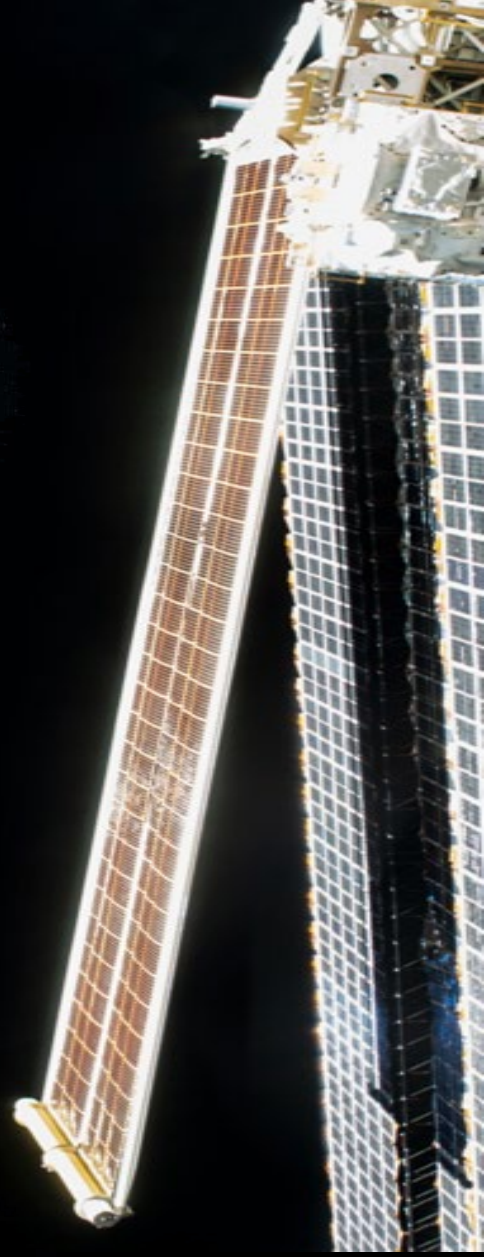
DART ROSA Impact







Questions



Thank you for your time and consideration!

Questions or More Info: matt.lapointe@redwirespace.com