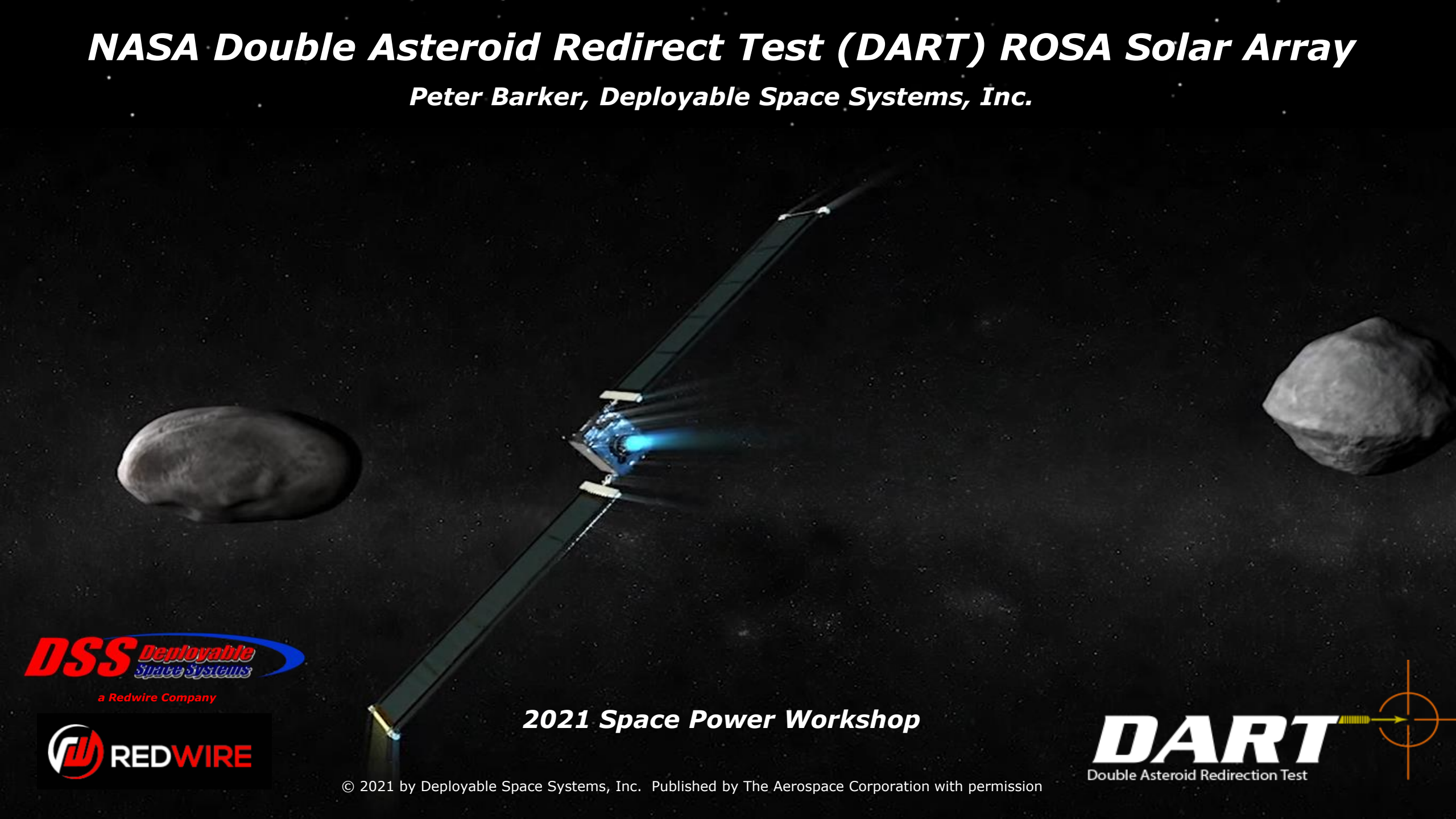
NASA Double Asteroid Redirect Test (DART) ROSA Solar Array

Peter Barker, Deployable Space Systems, Inc.



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2021 Space Power Workshop

DART
Double Asteroid Redirection Test

Outline

DART Mission Overview

DART SEP System

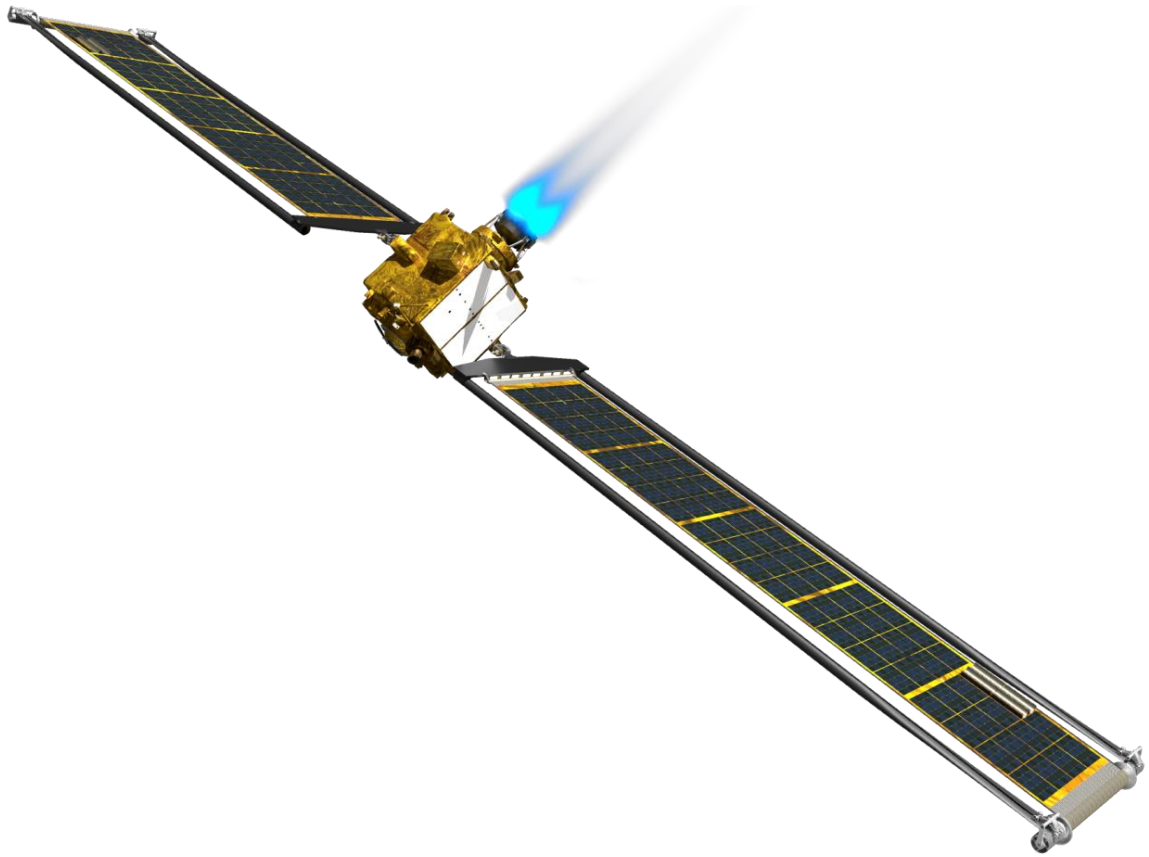
DART ROSA Solar Array Design

- Stowed and Deployed Configurations
- Mechanical and Electrical Subsystems

DART ROSA Protoflight Hardware

DART ROSA Protoflight Testing & Results

Summary



DART Mission Overview

NASA DOUBLE ASTEROID REDIRECT TEST (DART) ROSA SOLAR ARRAY

NASA's DART mission: First-ever spacecraft to demonstrate asteroid deflection by kinetic impactor on an asteroid target

- Involves striking an asteroid to shift its orbit and deflect it from hitting Earth
- Mission is a critical step in understanding and demonstrating one of the approaches that could be used to protect Earth

DSS providing ROSA solar arrays under subcontract to JHU / APL

Launch window scheduled for November 24, 2021 – February 15, 2022

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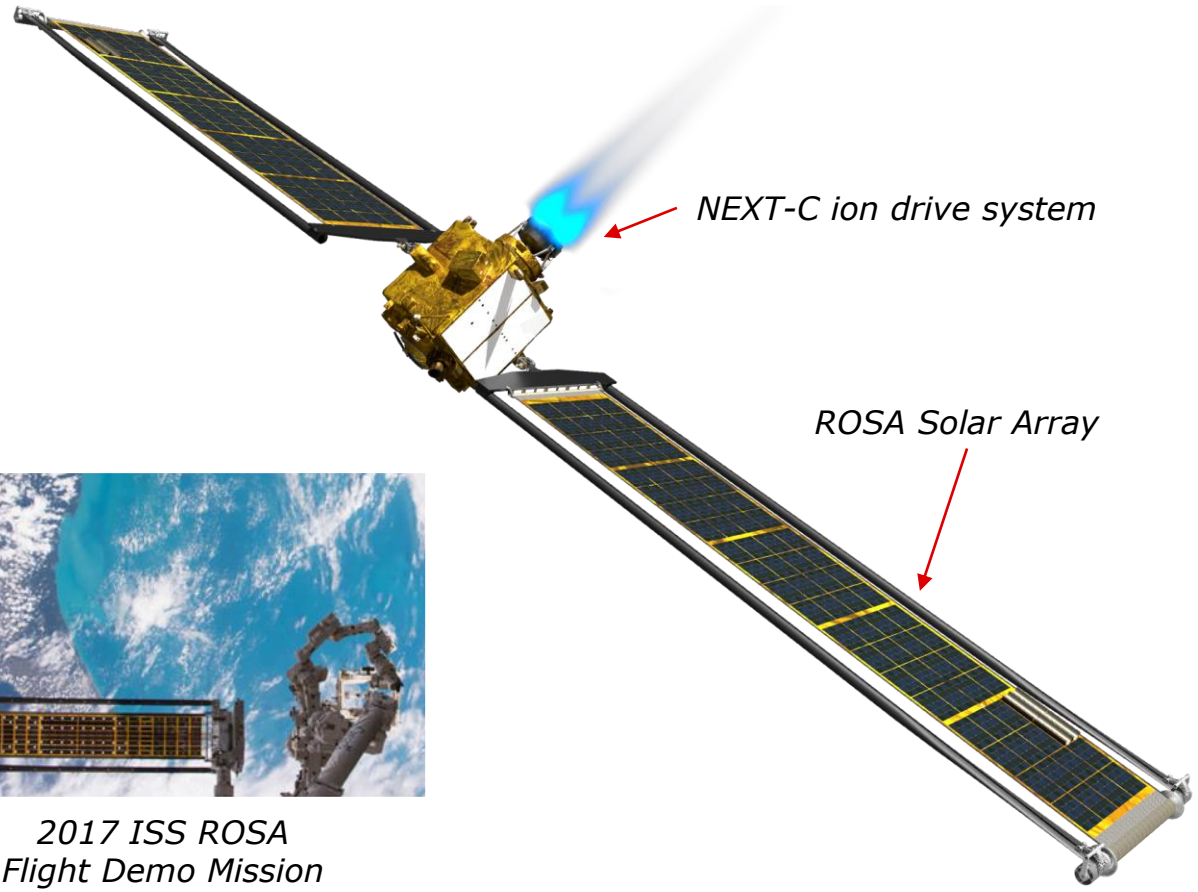
DART SEP System

ROSA & NASA'S NEXT-C

DART SEP system comprised of DSS's ROSA solar array and NASA's Evolutionary Xenon Thruster–Commercial (NEXT-C) ion drive system

- Over significant time and interplanetary distances, ROSA and NASA's NEXT-C drive system has the capability of reaching up to 324,000 kilometers per hour, more than five times faster than the speedy Voyager 1 probe
- ROSA solar array provides more than 6.6 kilowatts power at BOL
- DART ROSA configuration adapted from the successful ISS ROSA flight demonstration mission in June 2017, increased length and width



2017 ISS ROSA Flight Demo Mission

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DART ROSA Major Driving Requirements

KEY REQUIREMENTS

BOL Power: >6.6kW

Mass: >100 W/kg

Two Power Segments

- 100V SEP segment and 60V spacecraft segment

Deployed Frequency: >0.25Hz

Stowed Frequency: >50Hz

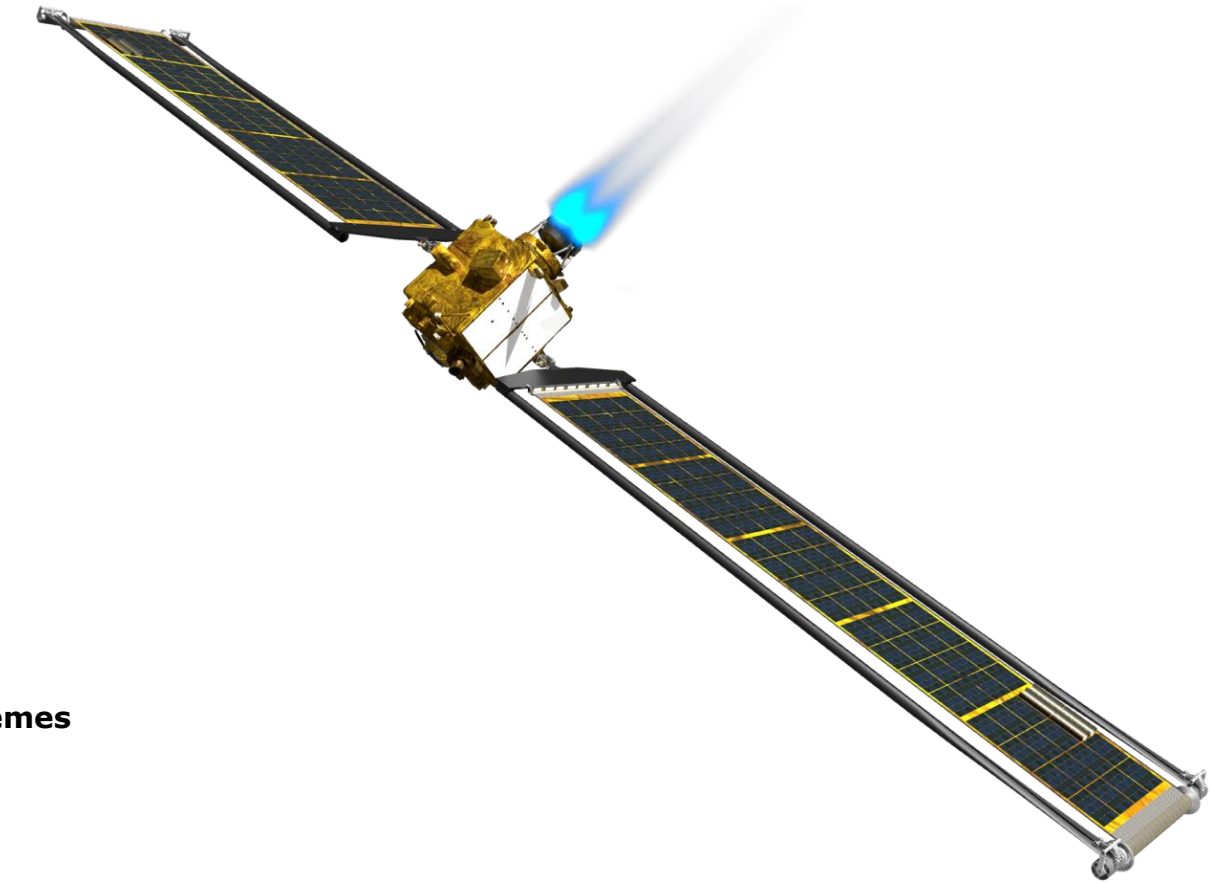
Launch Loads

- Design limit loads: 20G (X,Y,Z)
- Sine vibration loads: 18G axial (Z) & 8G lateral (X,Y)
- Random vibration loads: 14.1 gRMS (X,Y,Z)

Deployment torque margin: >3:1

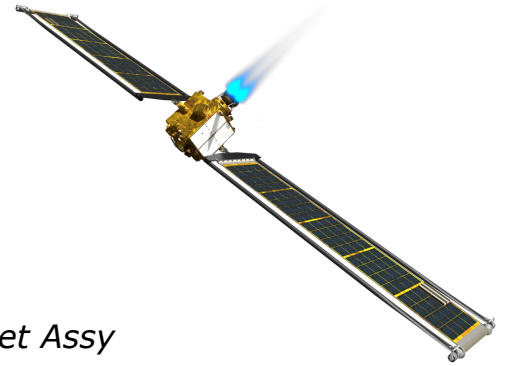
Functional Deployment at -65C and +52C Temperature Extremes

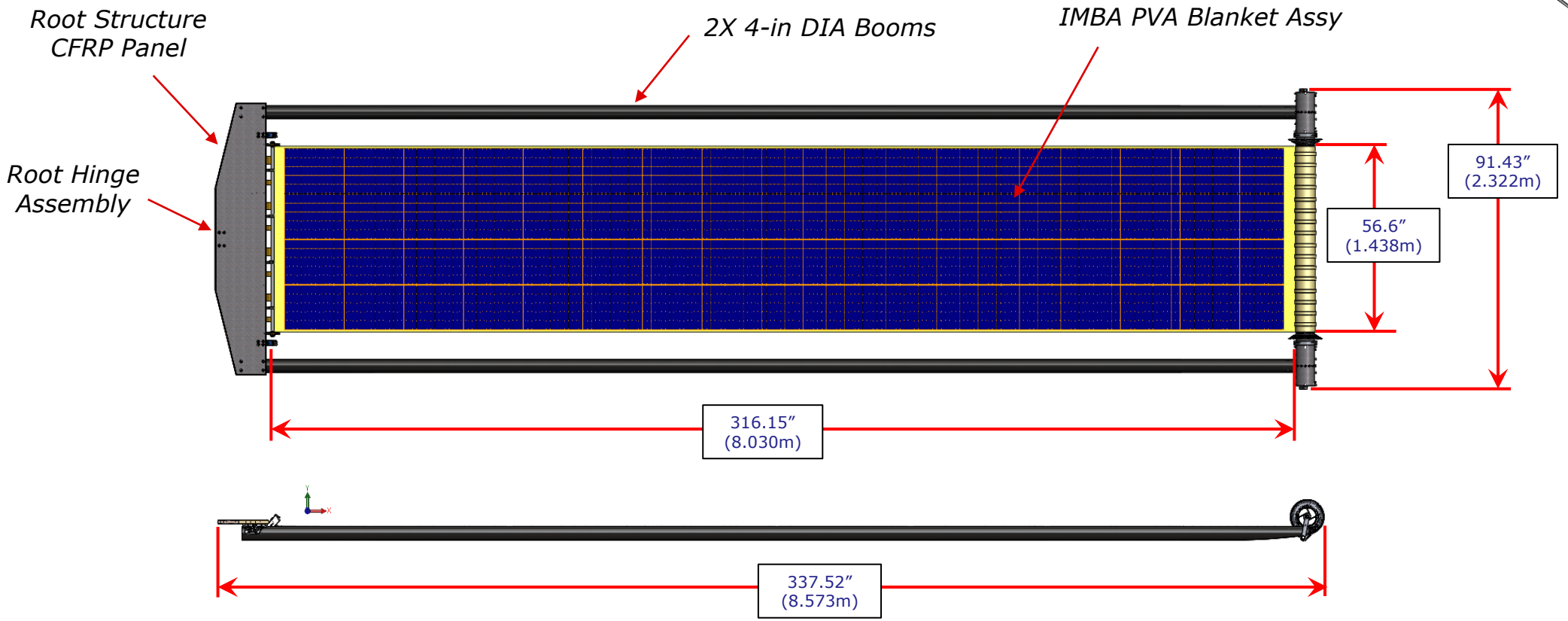
Compatibility and operability in a SEP plasma environment



DART ROSA Deployed Configuration

DEPLOYED & DIMENSIONS





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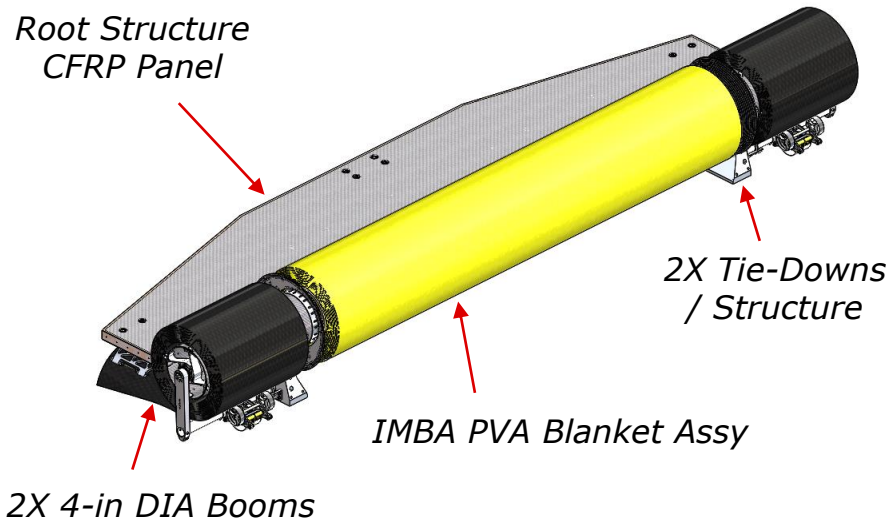
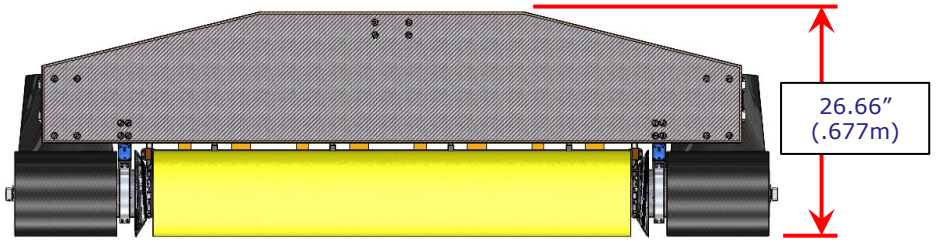
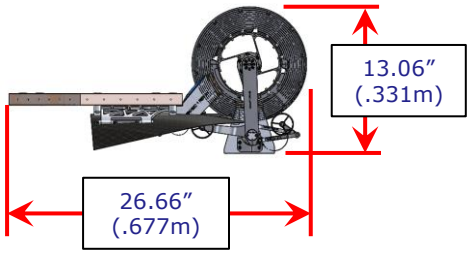
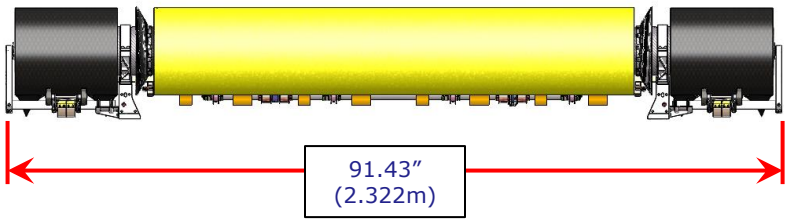
DART ROSA Stowed Configuration

STOWED & DIMENSIONS









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DART ROSA Solar Array Deployment Sequence

DEPLOYMENT ANIMATION

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DART ROSA IMBA PVA Blanket Assembly

IMBA CONFIGURATION

SPM tile configuration on IMBA

- 4 X 18 orthogonal matrix of SPM's

Two SPM configurations employed

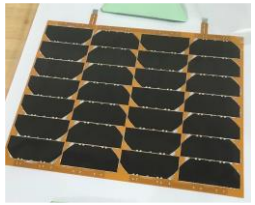
- Ion Propulsion Segment SPM's
  - 4 X 11 SolAero ZTJ CIC Matrix (100V)
- Spacecraft Segment SPM's
  - 4 X 7 SolAero ZTJ CIC Matrix (60V)

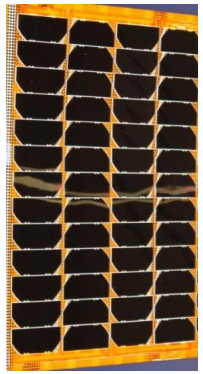
Electrical harnessing (backside)

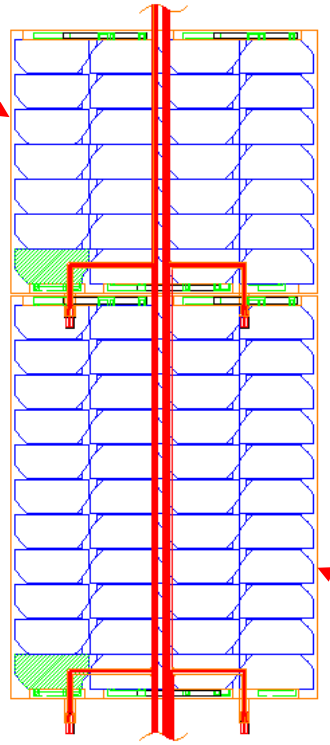
- Flex harnessing runs down each SPM column (4)
- Individual strings routed to blocking diodes / diode boards mounted on root structure

Electrical interface / connectors

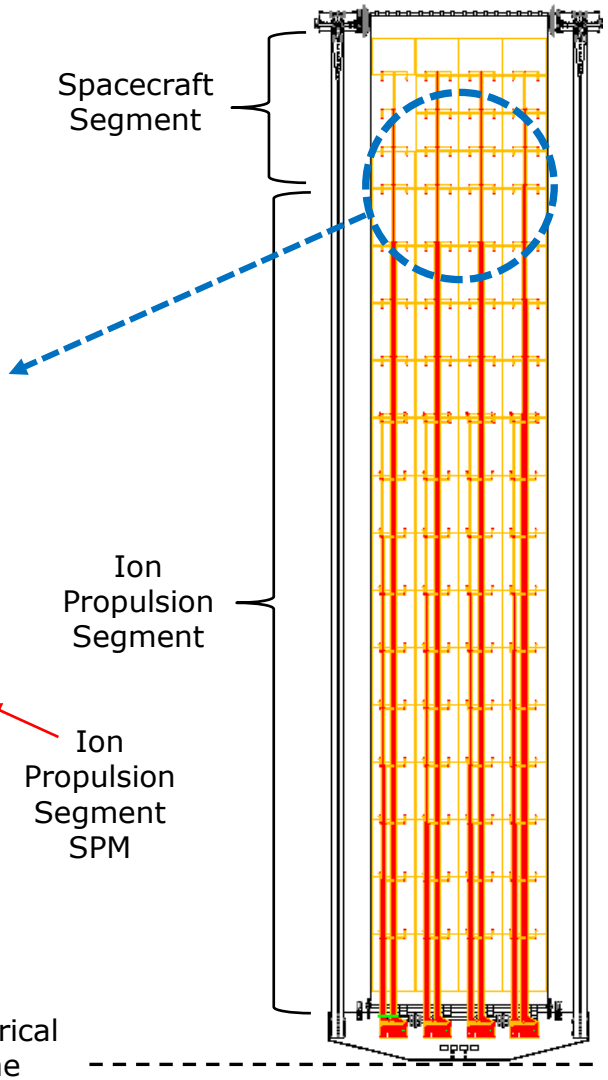
- Discrete circuit harness routed from diode board along root structure to interface connectors







SPM Column Detail



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Transformational Solar Array (TSA) Experiment

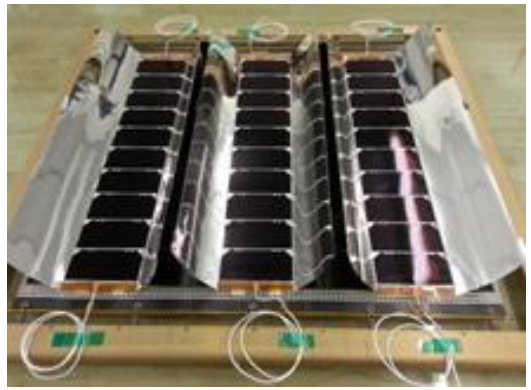
TSA ENABLES EXTREME ENVIRONMENTS MISSIONS

Two SPM positions of the DART ROSA have been configured to demonstrate the Transformational Solar Array (TSA)

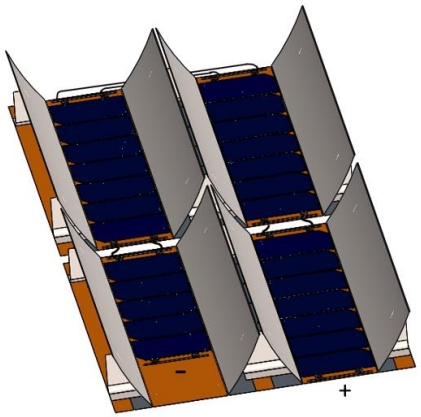
- TSA enables NASA's extreme environments missions

TSA SPM is comprised very-high-efficiency SolAero IMM 4J PVA and DSS's FACT reflective concentrator technology

- Dedicated harnessing to assess electrical performance during mission

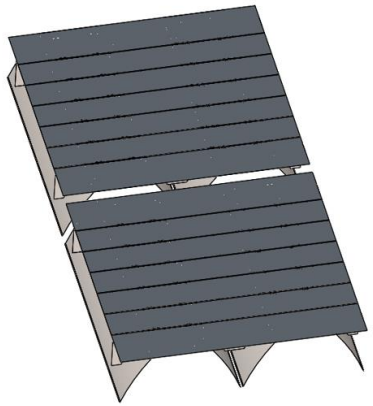


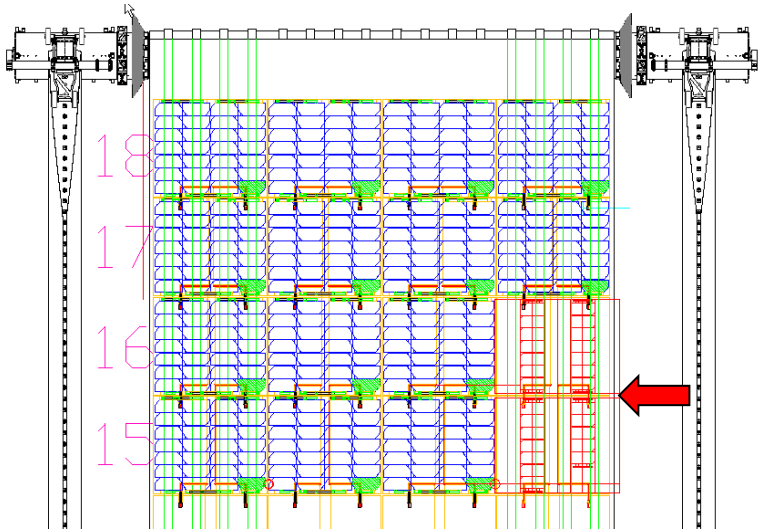
TSA-FACT-DART SPM



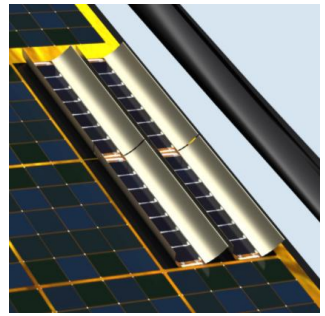
Frontside

Backside





TSA-FACT Concentrator Module
Location on DART ROSA Blanket



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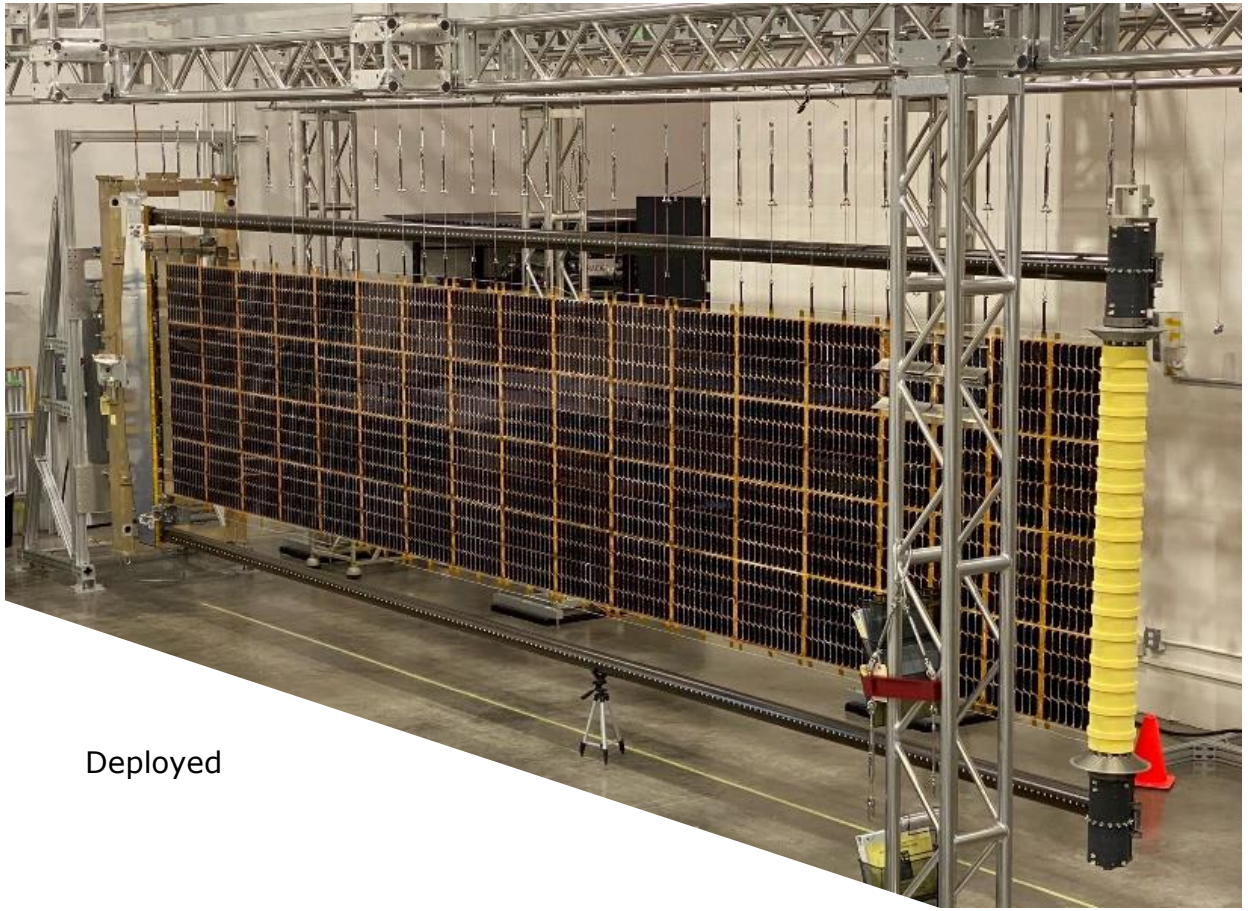
DART ROSA Solar Array Protoflight Hardware

DEPLOYED & STOWED



Deployed

Stowed

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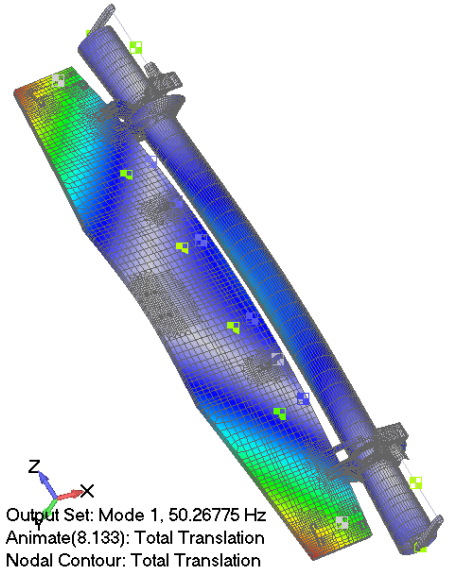
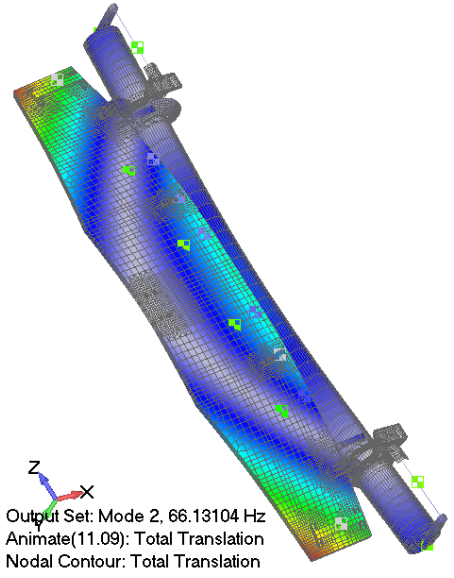
Stowed Stiffness / Frequency

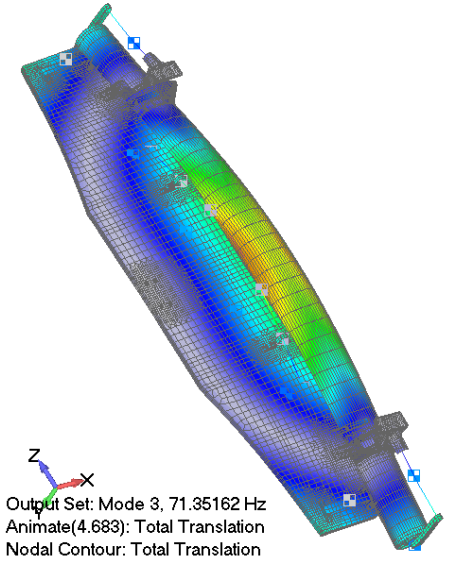
50.3 HZ STOWED FIRST MODE FREQUENCY

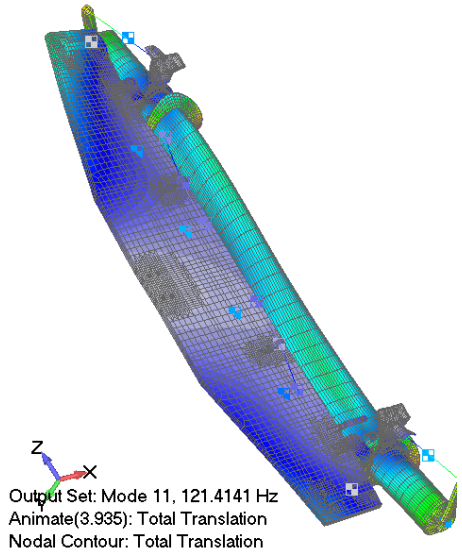
Predicted 50.3Hz first natural frequency compliant to requirement of 50Hz

First mode with significant S/C Z axis mass participation does not occur until > 120Hz





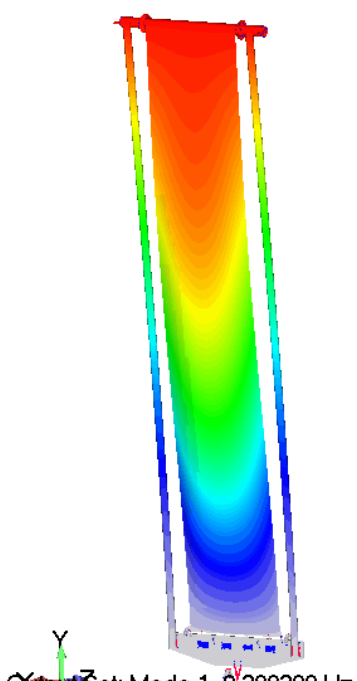




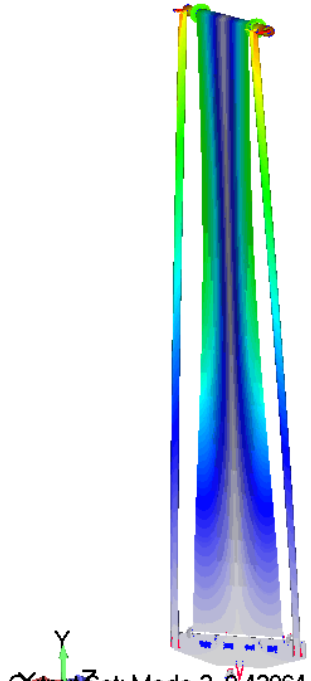
Deployed Stiffness / Frequency

0.29HZ DEPLOYED FIRST MODE FREQUENCY

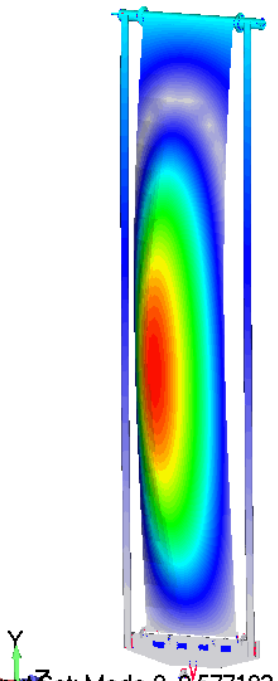
Predicted 0.29Hz first natural frequency compliant to requirement of 0.25Hz



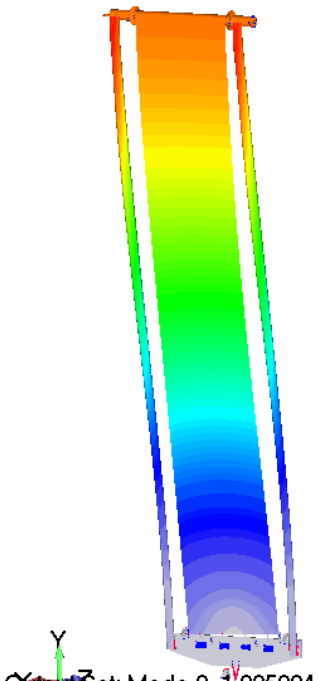
Output Set: Mode 1, 0.288209 Hz
Animate(3.284): Total Translation
Nodal Contour: Total Translation



Output Set: Mode 2, 0.42064 Hz
Animate(5.232): Total Translation
Nodal Contour: Total Translation



Output Set: Mode 3, 0.577182 Hz
Animate(5.83): Total Translation
Nodal Contour: Total Translation



Output Set: Mode 9, 1.035904 Hz
Animate(3.653): Total Translation
Nodal Contour: Total Translation

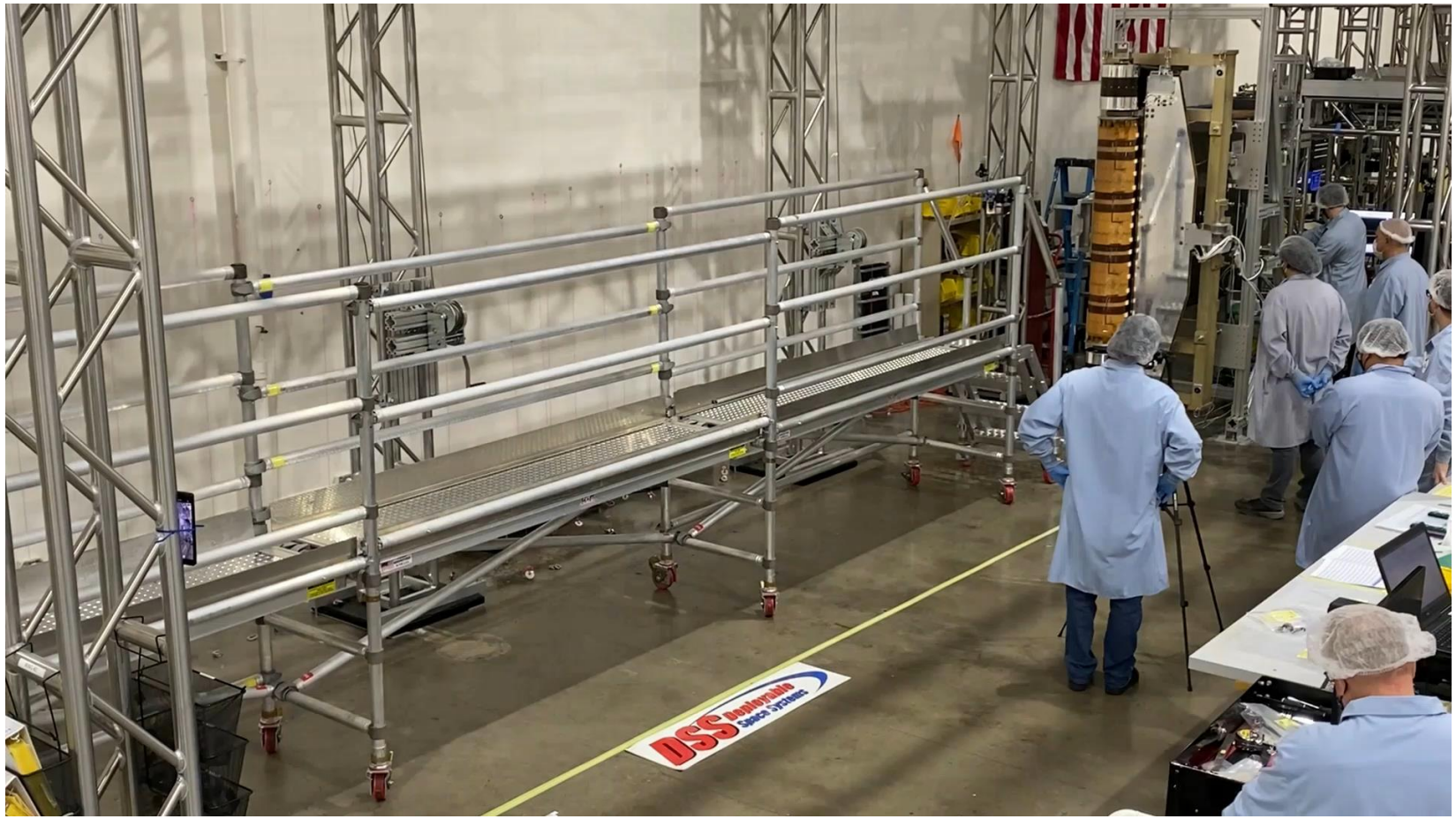
DART ROSA Wing-Level Protoflight Test Sequence

PROTOFLIGHT TEST SEQUENCE SUBJECTED TO BOTH WINGS

- **Pre-test / initial inspection and electrical performance verification, then Stowage**
- **Ambient functional deployment**
- **Inspection and electrical performance verification, then Stowage**
- **Random vibration**
- **Sine vibration**
- **Ambient functional deployment**
- **Inspection and electrical performance verification, then Stowage**
- **Stowed configuration thermal cycle (-75C to +52C)**
- **Cold temperature functional deployment (-65C)**
- **Inspection and electrical performance verification, then Stowage**
- **Hot temperature functional deployment (+52C)**
- **Post-test / final inspection and electrical performance verification, then Stowage**

DART ROSA Solar Array Functional Deployment

3X SPEED SHOWN - COMPLETE DEPLOYMENT ACHIEVED WITHIN 5-MINUTES



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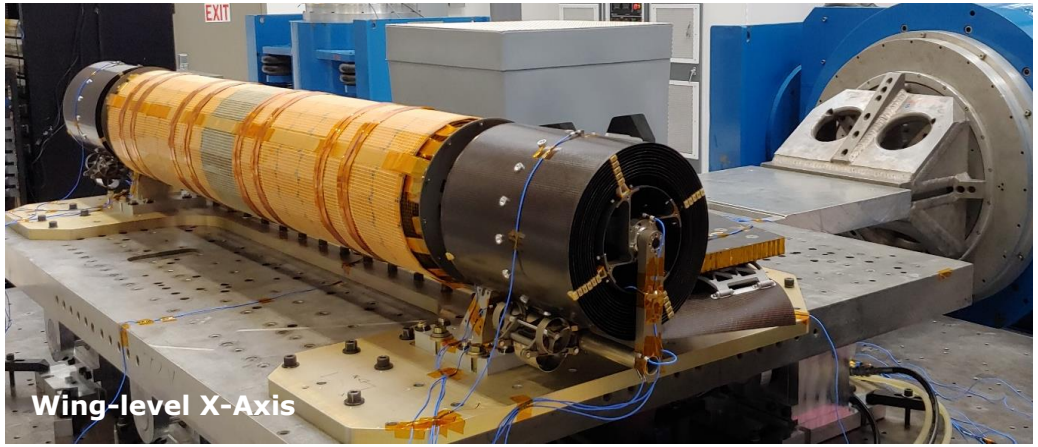
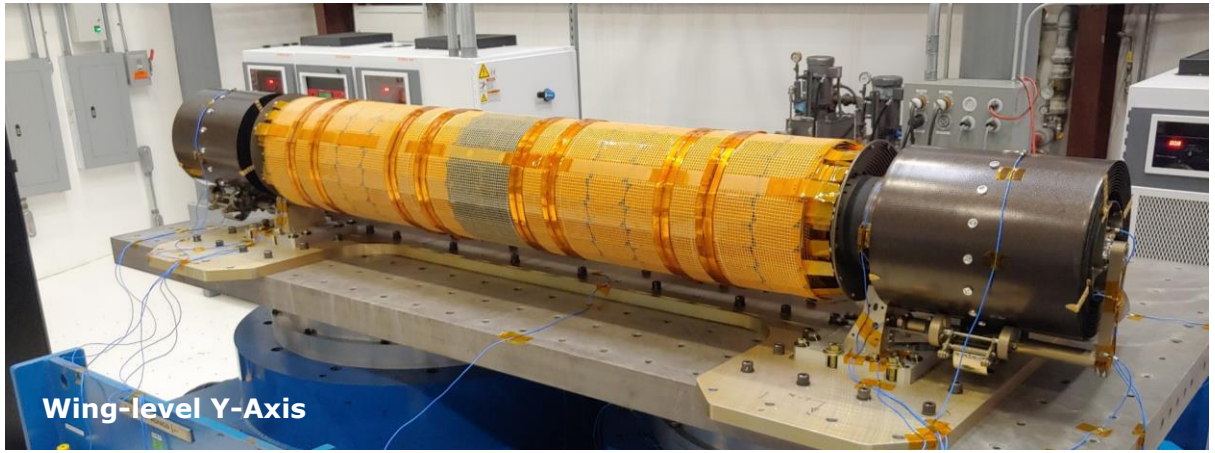
DART ROSA Solar Array Random and Sine Vibration

FULL WING-LEVEL & COMPONENT LEVEL. SINE: 18G (Z) & 8G (X,Y) & RANDOM: 14.1 GRMS (X,Y,Z)

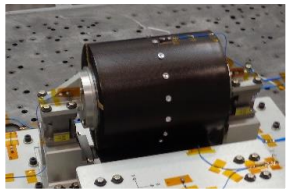


Wing-level X-Axis


Wing-level Y-Axis


Wing-level Z-Axis

Boom & IMBA
Component-level



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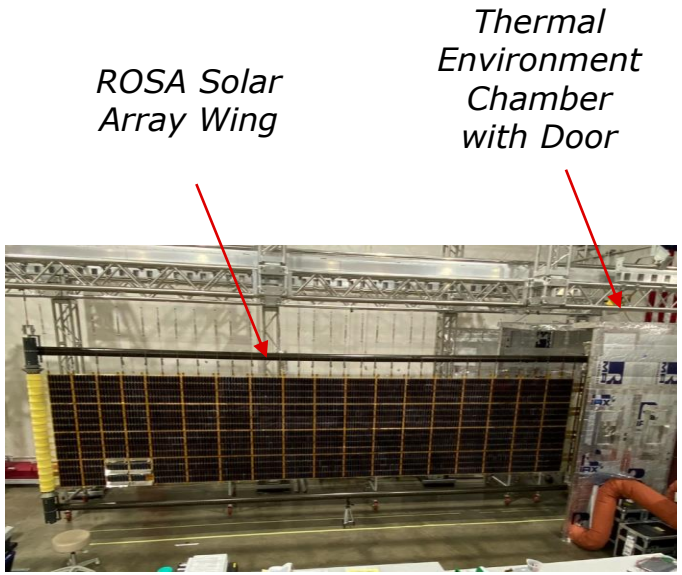
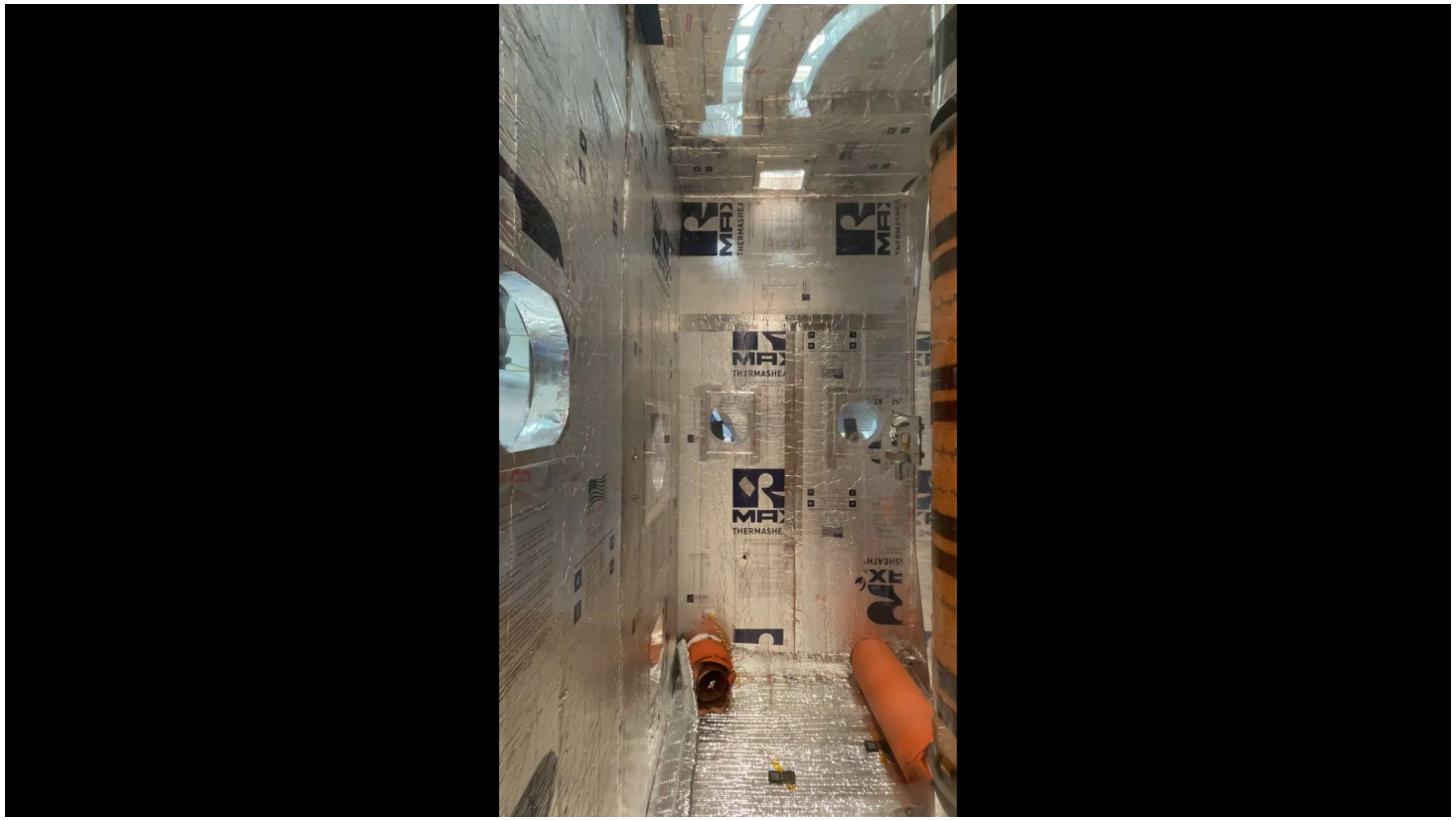
DART ROSA Solar Array Cold & Hot Functional Deployment

6-THERMAL CYCLES BETWEEN -75C & +52C THEN DEPLOYMENT AT -65C & +52C TEMPERATURE EXTREMES





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DART ROSA Solar Array Test Results Summary

BOTH DART ROSA WINGS SUCCESSFULLY PASSED THE PROTOFLIGHT TEST CAMPAIGN

No structural or electrical damage / degradation

- Only 3-cracked solar cells in entire array

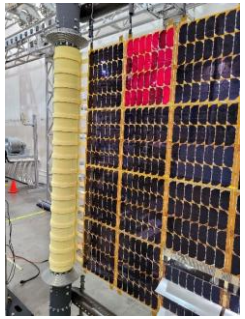
No measurable degradation in electrical performance

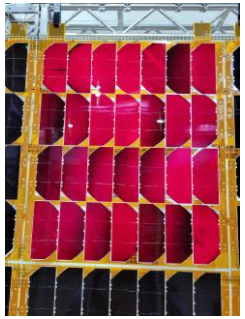
Structural and electrical survivability validated to very high quasi-static, random and sine vibration loads

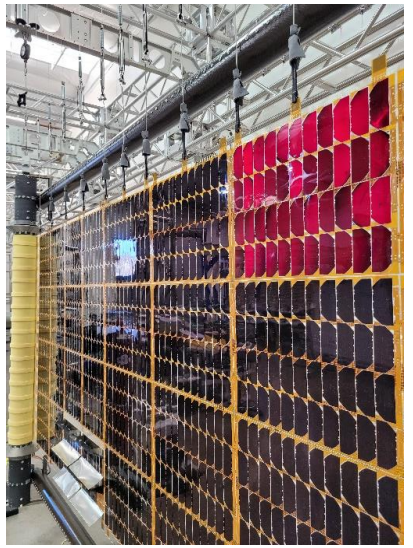
Repeated functional deployments validated in ambient, cold and hot temperature environments

Deployment torque margins >3:1 validated in ambient, cold and hot temperature environments

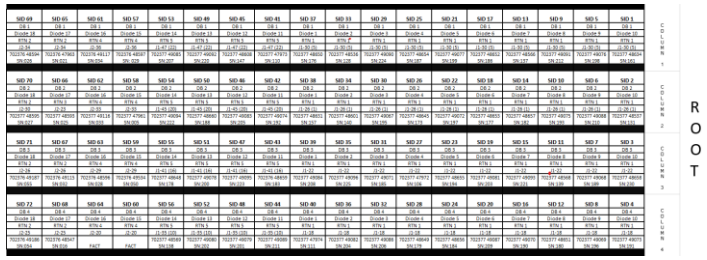
Forward Bias Illumination with Visual Inspection







Dark IV Mapping & Characterization



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Summary

DART ROSA SOLAR ARRAY

NASA's DART mission is the first-ever spacecraft to demonstrate asteroid deflection by kinetic impactor on an asteroid target

DART's SEP system is comprised of DSS's ROSA solar array and NASA's Evolutionary Xenon Thruster–Commercial (NEXT-C) ion drive system

Two DART ROSA Solar Array protoflight wings have been produced, validated through test, and delivered to the APL

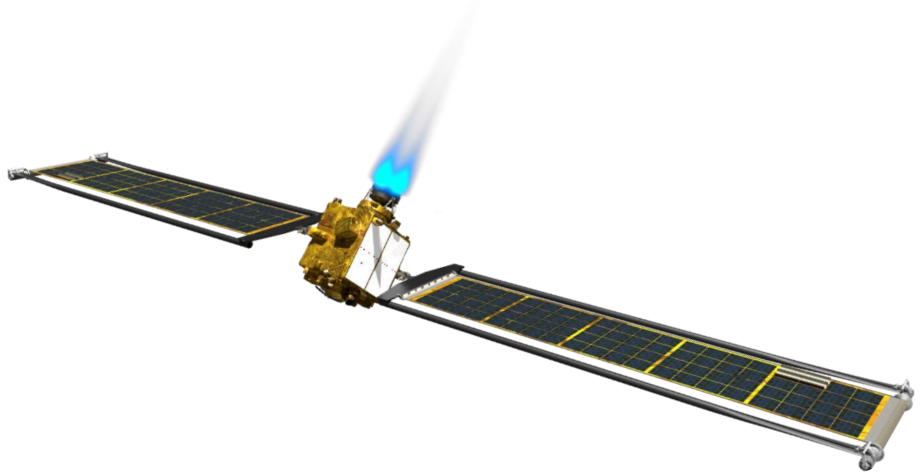
The DART ROSA solar array met all structural, mechanical, and electrical requirements

- BOL power, 100W/kg, launch loads survivability, and deployed and stowed stiffness performance requirements met

This power-class/size of ROSA is now qualified through the DART program and is ready for infusion into follow-on flight programs

- Maxar's Ovzon is the first commercialization of this class/size

DART launch window to 'save the world' is scheduled for November 24, 2021 – February 15, 2022



Acknowledgments

THANK YOU JHU/APL & NASA

DSS sincerely expresses thanks and appreciation to the DSS DART team, and the JHU/APL and NASA DART teams for their sponsorship and programmatic / technical leadership and in helping DSS execute this successful program

Thank you for your time and consideration !

Innovate or Die !