NASA Double Asteroid Redirect Test (DART) ROSA Solar Array

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a Redwire Company



2021 Space Power Workshop



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Outline

DART Mission Overview

DART SEP System

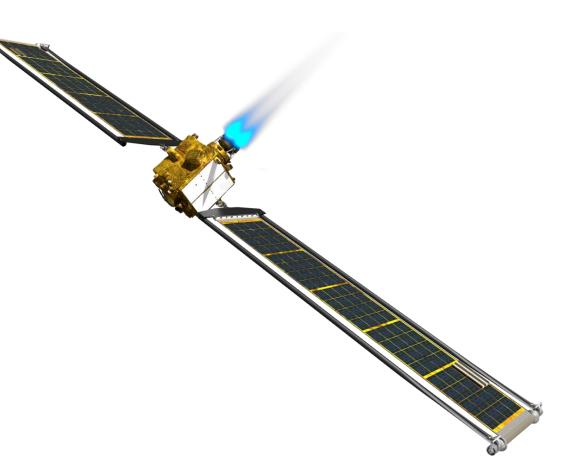
DART ROSA Solar Array Design

- 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





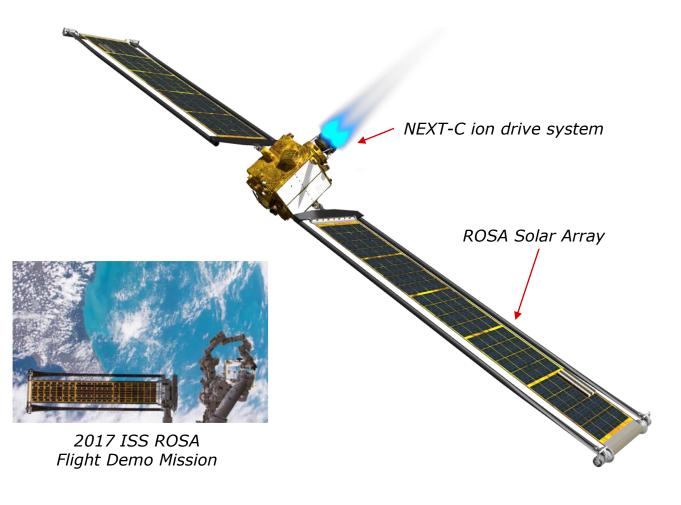


DART SEP System

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







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

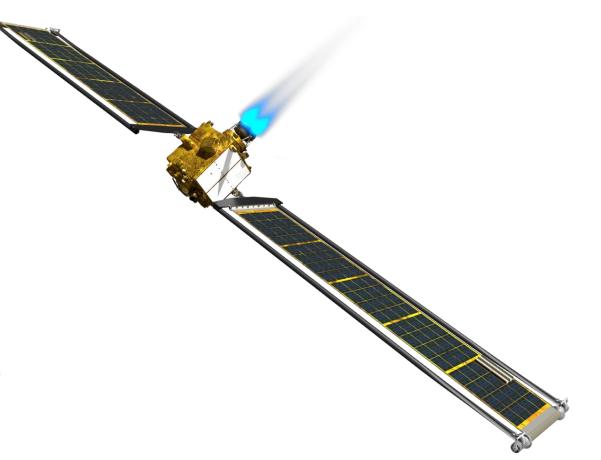
Launch Loads

- 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

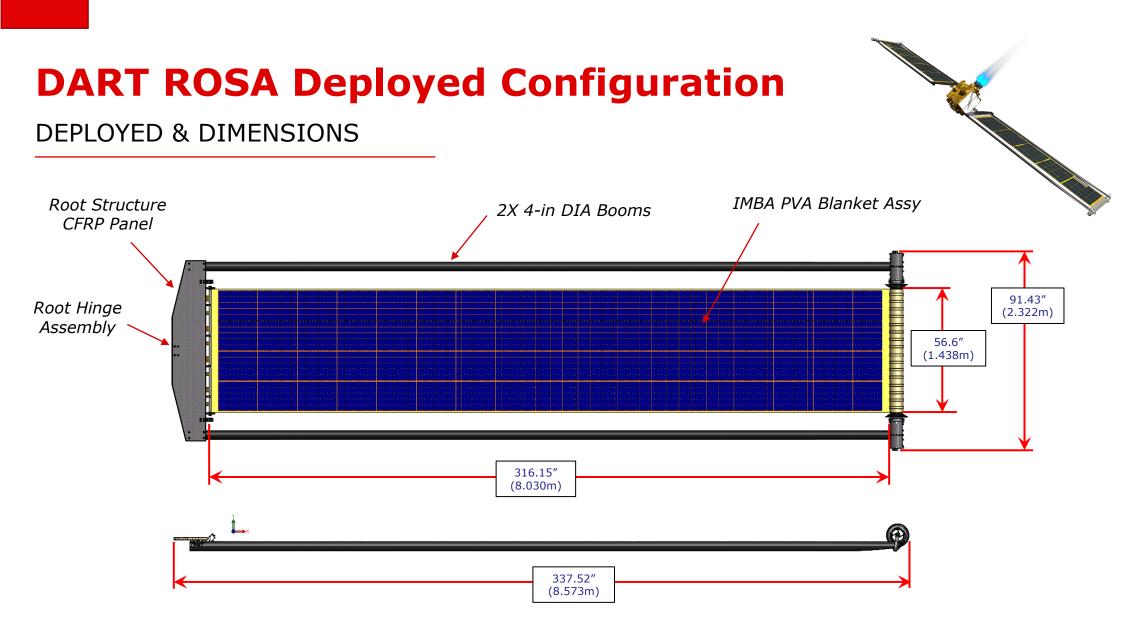
Functional Deployment at -65C and +52C Temperature Extremes

Compatibility and operability in a SEP plasma environment









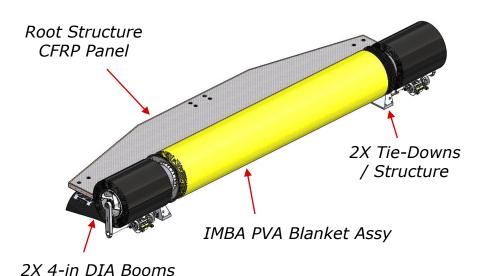


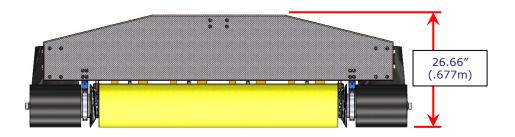


DART ROSA Stowed Configuration

13.06" (.331m)

STOWED & DIMENSIONS

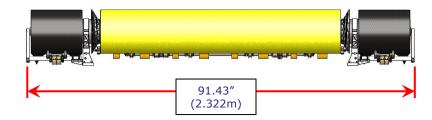






VIRE

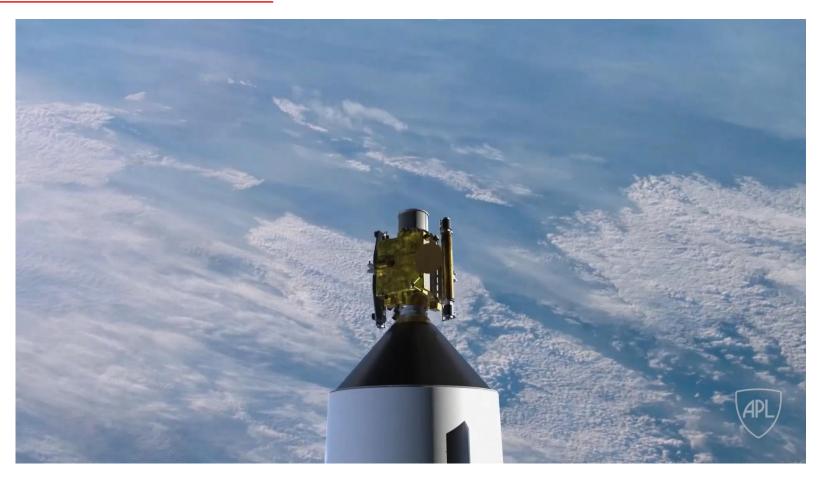
26.66″ (.677m)





DART ROSA Solar Array Deployment Sequence

DEPLOYMENT ANIMATION







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)

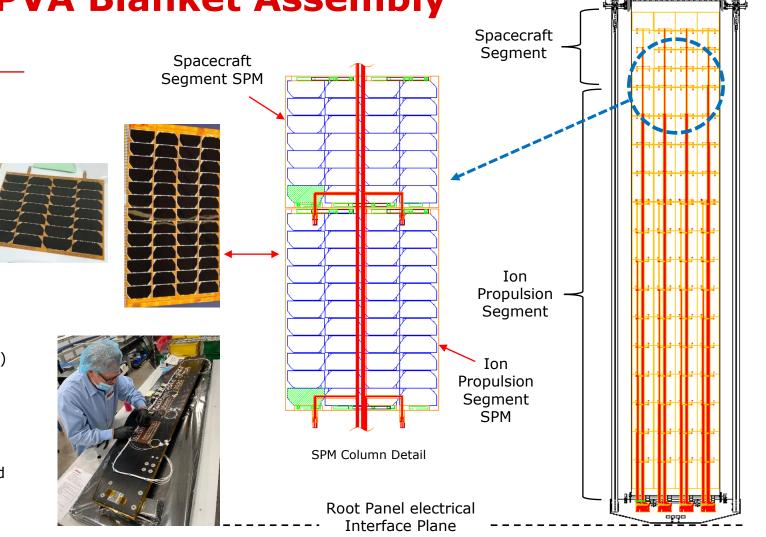
Electrical harnessing (backside)

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

Electrical interface / connectors

VIRE

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





Transformational Solar Array (TSA) Experiment

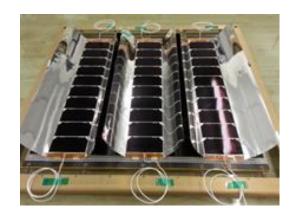
TSA ENABLES EXTREME ENVIRONMENTS MISSIONS

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

TSA enables NASA's extreme environments missions

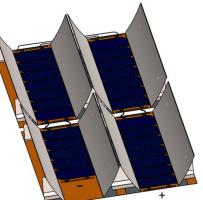
TSA SPM is comprised very-high-efficiency SolAero IMM 4J PVA and DSS's FACT reflective concentrator technology

• Dedicated harnessing to assess electrical performance during mission



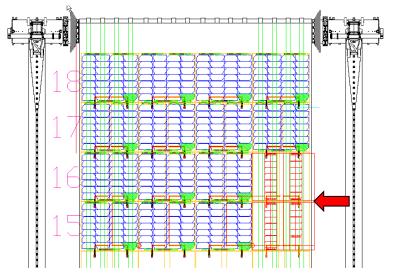
TSA-FACT-DART SPM

Backside

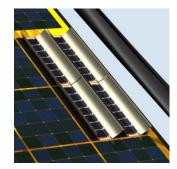




Frontside



TSA-FACT Concentrator Module Location on DART ROSA Blanket

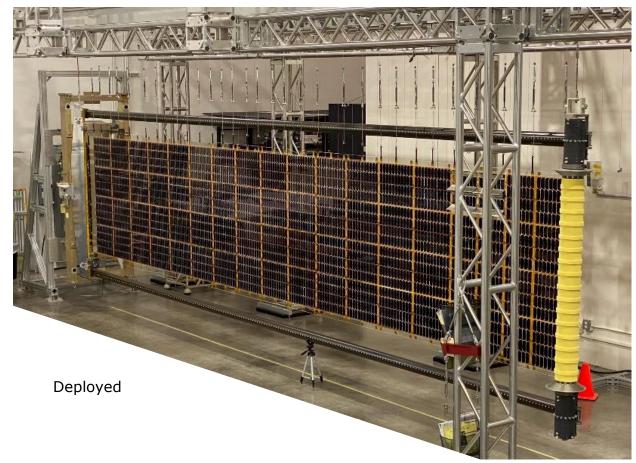


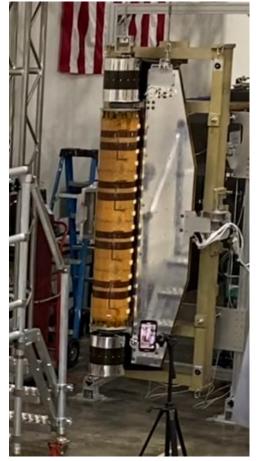




DART ROSA Solar Array Protoflight Hardware

DEPLOYED & STOWED





Stowed



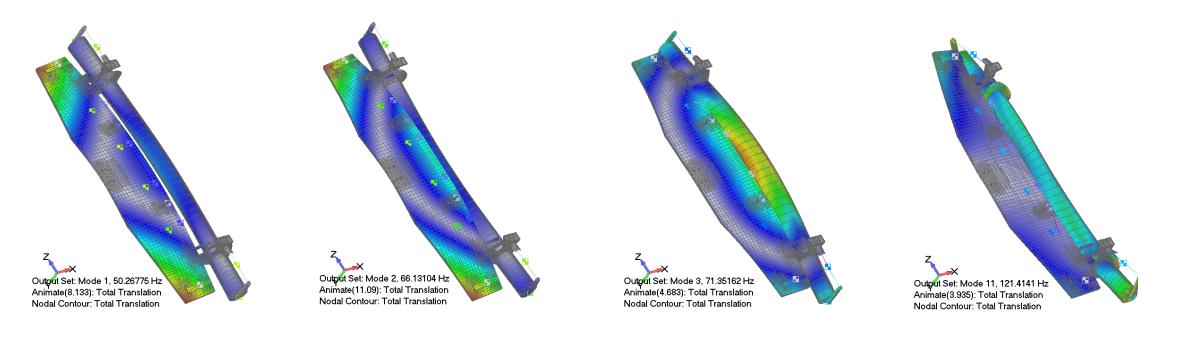


Stowed Stiffness / Frequency

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





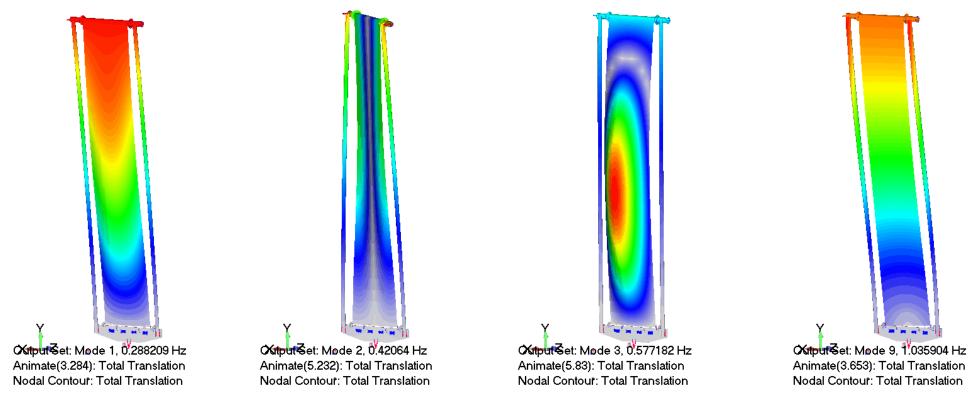


Deployed Stiffness / Frequency

0.29HZ DEPLOYED FIRST MODE FREQUENCY

WIRE

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





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







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)





Boom & IMBA Component-level



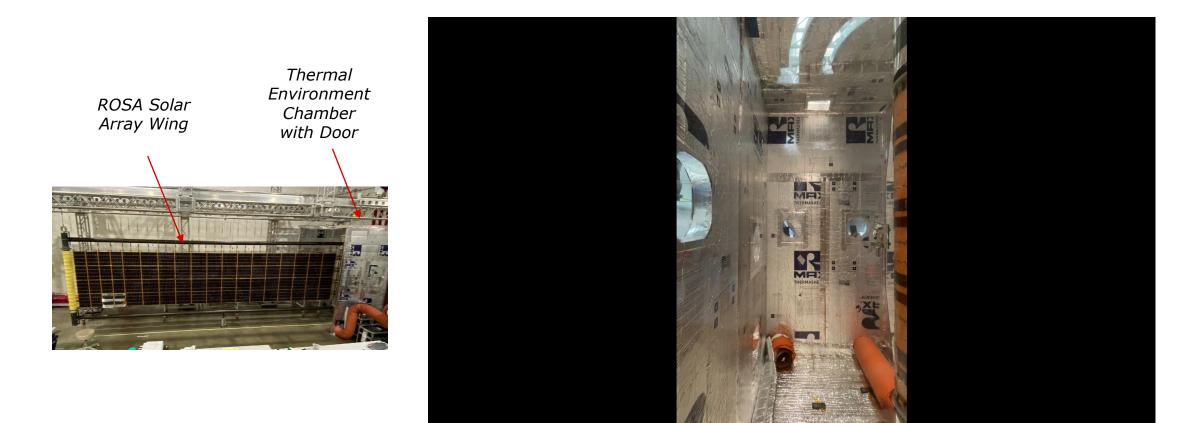






DART ROSA Solar Array Cold & Hot Functional Deployment

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







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

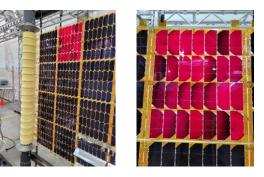
Repeated functional deployments validated in ambient, cold and hot temperature environments

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

Dark IV Mapping & Characterization

U M 134 N	SID 1 Di cole 10 MTN 1 J2:50(3) 572377 48094 SNI 50 SID 2 Di 22 Di 22	580 5 Di 1 Di 055 9 #751 1 702377 49075 551228 580 6 Di 05 9 #751 1 Di 058 9 #751 1	54D 9 Dis 1 Dis 54 8 87N 1 JI-50 01 702377 48091 5N 212 5N 212 5N 212 5N 212 5N 212 5N 212 5N 212 5N 212	SID 13 08 1 Diside 7 81N 1 13:33 (5) 702377 45565 59:337 SID 14 06.2 Diside 7 81N 1	SID 17 Dister 6 PTN 1 Dister 7 PTN 1 DISTER 7 DISTER 7 DISTER 7 DI	SID 21 08 1 Disole 5 8171 1 12:59 150 702577 49077 59199 SID 22 06 2 Disole 5 8171 1	540.25 08.1 Dicost-4 #TN 1 12-35131 702337.48554 554287 540.26 Cito.2 Dicost-4 #TN 1	540 29 Di 00 1 Di 00 2 8175 1 7025377 48090 555 224 540 30 05 2 Di 00 2 Di 00 2 8775 1	540 83 26 1 Disster 2 mm f 23:3011 702377 48536 540 84 56 2 Disster 2 840 84 26 2 Disster 2 840 14	SID 37 D8 1 Diode 1 11-50 01 702377 48650 SN 276 SID 38 D05.2 Diode 1 870 1	SID 41 08 1 Diode 11 81% 5 32-47 (22) 702577 47975 5% 120 SID 42 06 2 Diode 11 81% 5	SID 45 Diode 12 PTN 5 J1-47 (22) 7022377 48008 SV247 SID 46 Diode 12 ETN 5	SID 49 08 1 Diste 13 8171 5 31-47 (22) 702577 49082 576 225 SID 50 06 2 Diste 13 8171 5	580 53 08 1 Disse 14 #78 3 11-67 1221 702337 48085 59-207 580 54 08 2 Disse 14 R78 5	5HD 57 Diside 15 mm 4 J2:36 702374 48587 59: 029 SHD 58 Di 2 Di ode 15 mm 4	540.61 Disole 16 #7114 10:39 702378-49117 59(5)4 540.62 Disole 16 #7114	540.65 Di 1 Di ode 17 17.54 702376-47463 5N 521 SHD 66 DS 2 Di ode 17 810.66	580 69 04 1 Diode 38 81N 2 12-54 28:025 580 70 06 2 Diode 38 81N 2
57 N	12-26 (2) 702577 48557 5N 153	.72-28-(1) 702577 49088 5%210	J1-25 (1) 702577 49075 5N 293	J2-28 (1) 702577 48657 591382	11-26 (D) 702377 48855 5N:177	10-28 (1) 702577 49072 59(197	12-28-(2) 702577-48645 5N:173	J2-26 (3) 702577 49067 5N 195	J3-28-(1) 7025177-48600 576:340	J1-26 (U) 702577 48652 5N 257	70-45 (20) 702577 49074 5% 292	/1-45 (28) 702577 40085 5N 205	JD-45 (28) 702577 48660 591,188	J1-45 (20) 702577 40094 5%222	12-55 702577 47961 5N:005	10-55 702577 49114 59(033	J2-23 702577 48995 5N 025	12-93 702577 48595 594.027
	SID 3	SID 7	SID 11	SID 15	SID 19	510 23	SID 27	SID 31	SID 35	SID 39	SID 43	SID 47	SID 51	SID 55	SID 59	580.63	SID 67	SID 71
L L	DB 3 Diade 10 RTN 1 /1-22	28.3 Diode 9 87% 1 73-22	Diode 8 RTN 1 II-22	Dipde 7 87N 1 J0-22	06.3 Diode 6 RTN 1 11-22	C6 3 Diode 5 RTN 3 ID-22	26.3 Diode 4 RTN 1 12-22	D6 5 Diode 3 RTN 1 /1-22	Diode 2 87N 1 /2-22	Diode 1 87N 1 J1-22	Diode 11 87N 5 72-41 (16)	Diode 13 87% 5 /1-41 (36)	Diode 13 RTN 5 JD-41 (16)	Dipde 14 RTN 5 J1-41 (06)	Cipcle 15 RTN 4 J2-29	Diode 16 879-4 2-29	Diode 17 81N 2 12-26	Diode 38 87N 2 72-25
58 N	Ciede 10 RTN 1 /1-22	Diode 9 8/0v 1 75-22	Diode 8 87N 1	Dipde 7 85N 1	Older 5 RTN 1	RTN 3	Cipde 4 RTN 1	Diode 3 RTN 1	Diode 2 RTN 1	Diode 1 8TN 1	Diode 31 85N S	Diode 12 £7N 5	Diode 13 RTN 5 JD-41 (16)	Dipde 14 RTN 5	Cipcle 15 RTN 4 J2-29	Diede 16 87N-4	Diode 17 81N 2	attw 2

Forward Bias Illumination with Visual Inspection









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 !



