MMA's Low-Profile, CubeSat SADA (Solar Array Drive – v2.0)

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Presented to the 2024 CubeSat Developer's Workshop
CalPoly University

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The Team:

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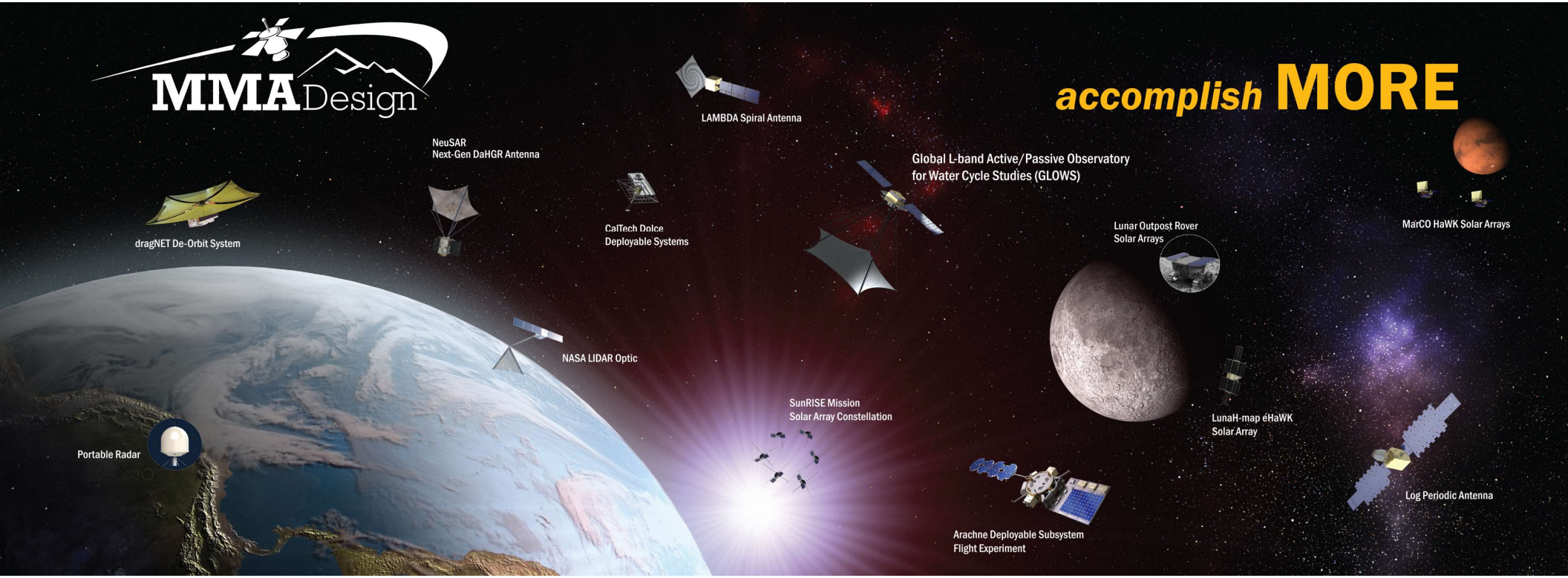
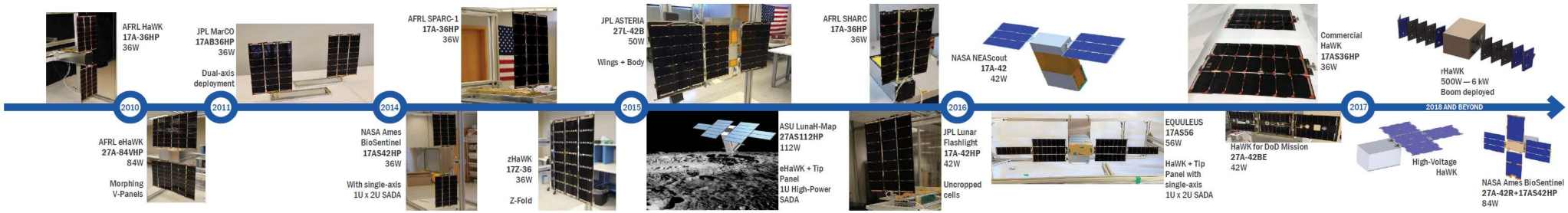
- Brent Gordon (Senior Mechanical Engineer)
- Andrew Haynes (Senior Mechanical Engineer)
- Alexi Rakow (Chief Engineer)

MMA Design, LLC
Current or Past Missions



MMA HaWK Solar Array Evolution

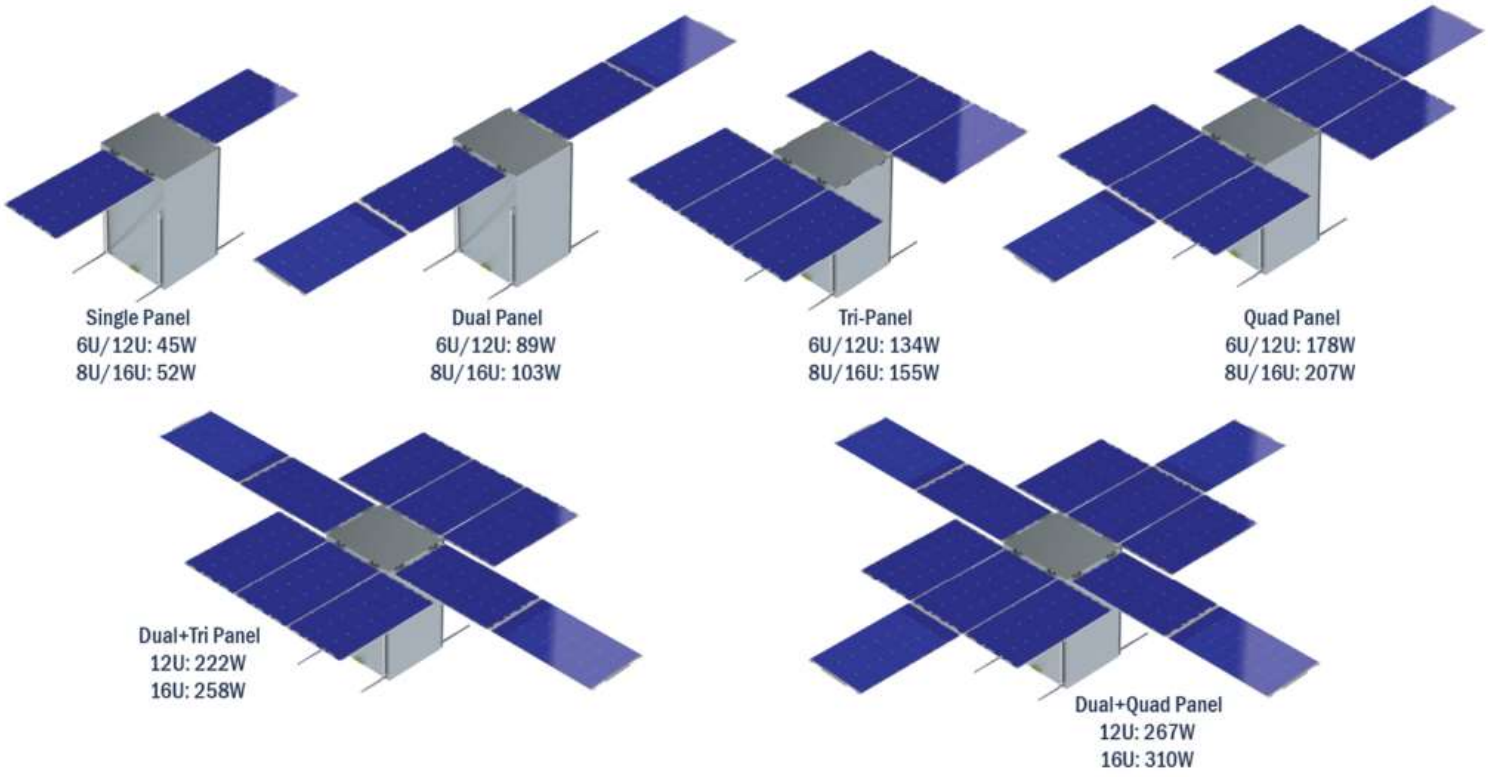


Existing Solar Array Configurations

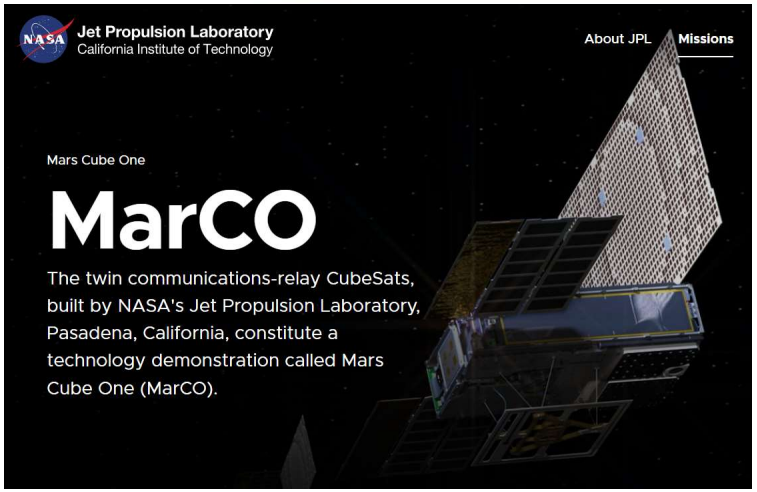
Existing HaWK Configurations

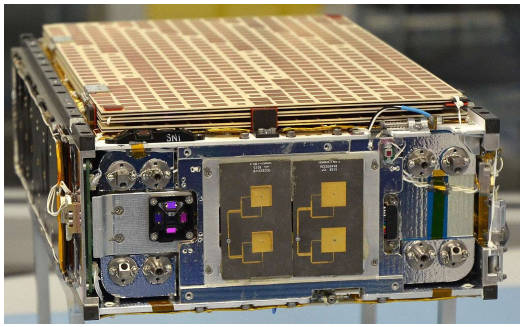
Wing			Array Performance		W/kg (without SADA)		Stowed Height (mm)	MMA HaWK Model Number
Stowed Footprint (U)		Deployment Axis	Panels per Wing	Peak Power* (2 wings)	Standard	High Performance		
1 x 3		α	3	42 W	99	127	7	17A-42
		α + ß(90deg)	3	36 W	96	129	6.5	17AB36
		α + SADA(ß)	3	42 W	99	127	6.5	17AS42
			4	56 W	91	155	8.5	17AS56
		α(long) z-fold	3	36 W	95	-	8	17Z-36
2 x 3	V-Panel	α	3	89 W	90	117	9.7	27A-89FV
	Flat Panel	α + SADA(ß)	4	118 W	97	121	11	27AS118
	Optimized	α	1	48 W	93	112	7	38A-48
			2	95 W	102	126	7	38A-95
			3	143 W	106	132	9	38A-143
			4	191 W	108	135	12	38A-191
2 x 4	Optimized	α	1	59 W	89	107	7	38A-59
			2	118 W	100	123	7	38A-118
			3	176 W	104	130	9	38A-176
			4	235 W	106	133	12	38A-235
ESPA		Boom-deployed + SADA(ß)	Multi-panel	~500 W - 6 kW	100 - 130		115	rHAWK

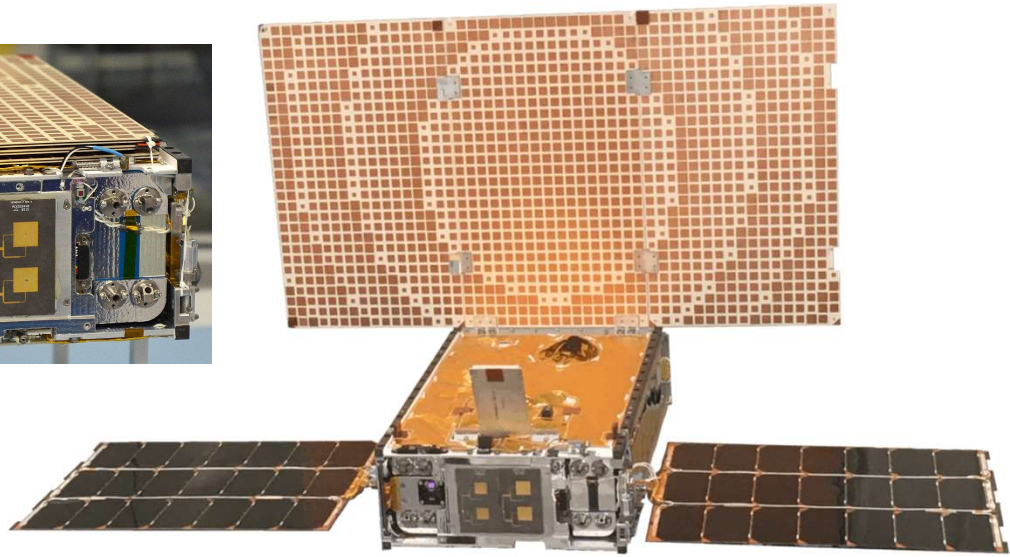
Optimized HaWK

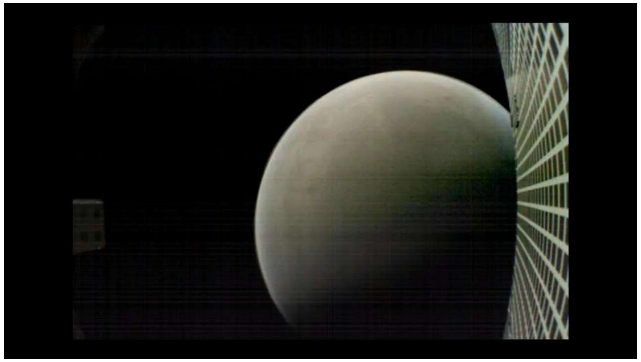


Mars CubeSat One (MaRCO)

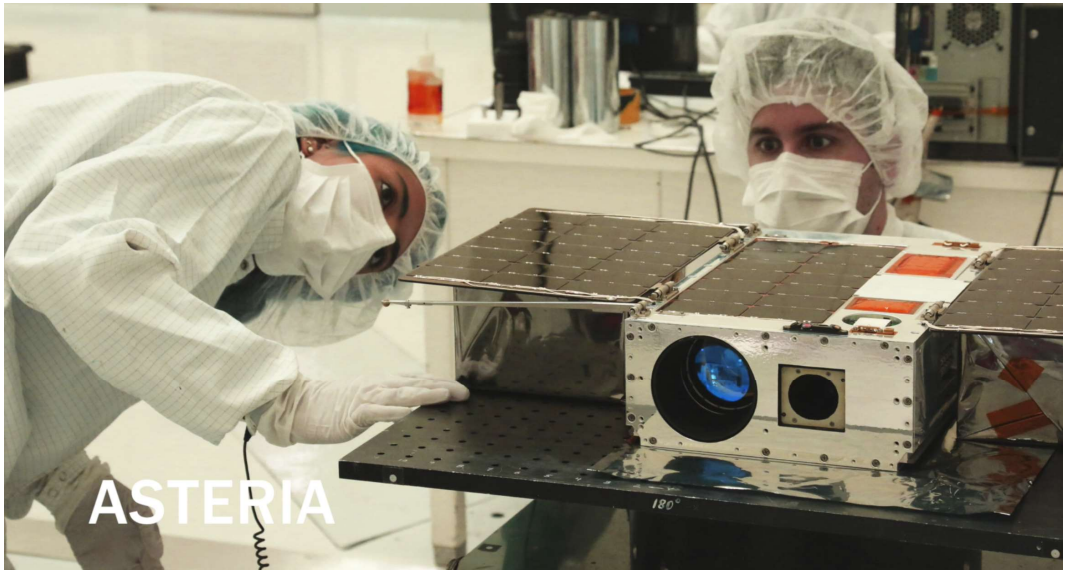








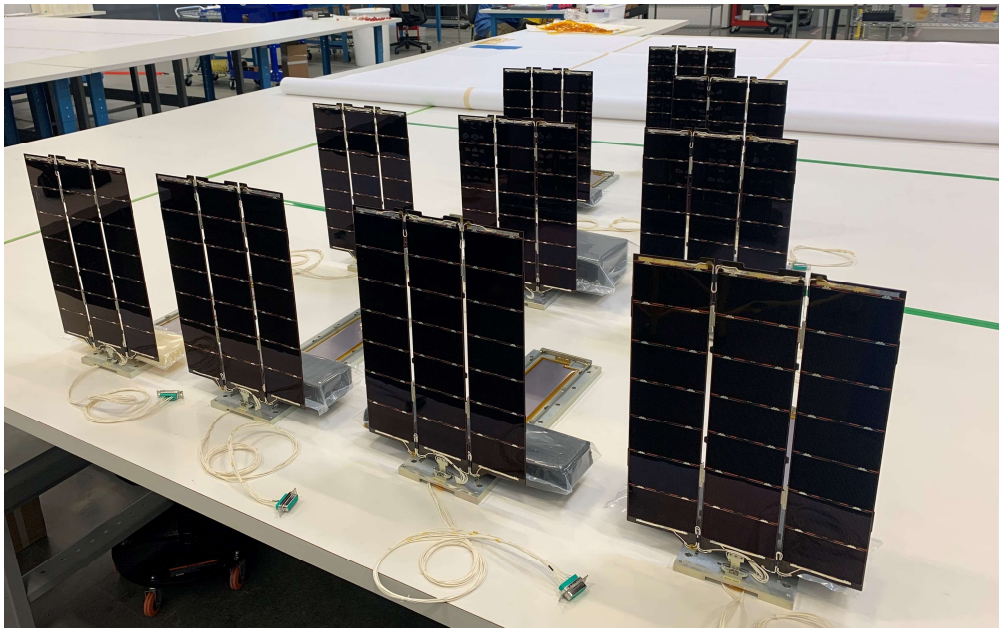
ASTERIA
(Launched Aug 14, 2017)

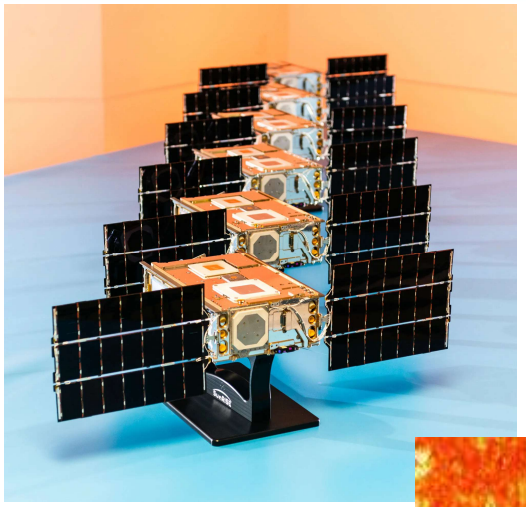


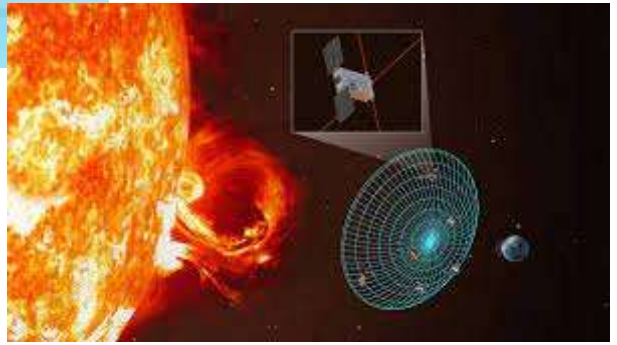
SunRISE

Sun Radio Interferometer Space Experiment

(NASA Launch 2024)

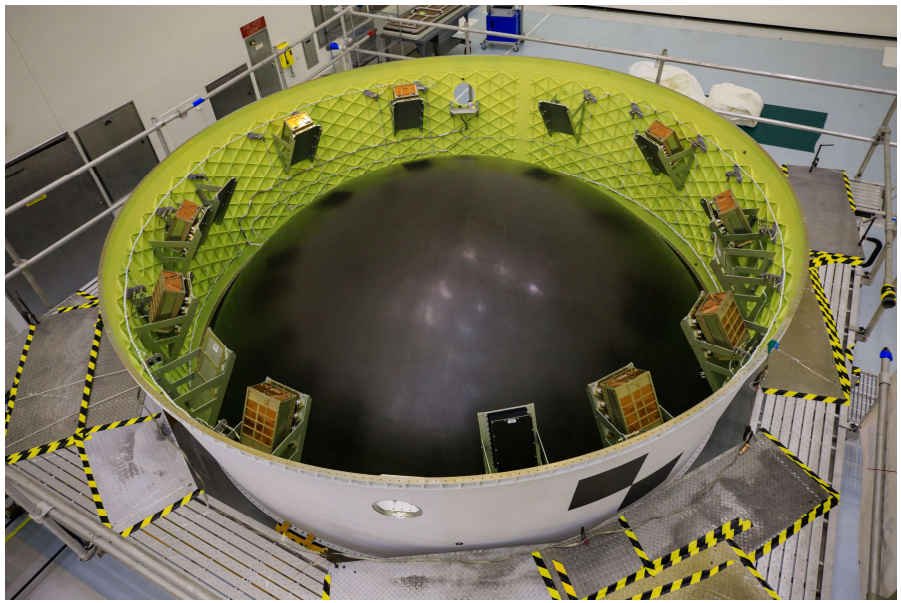


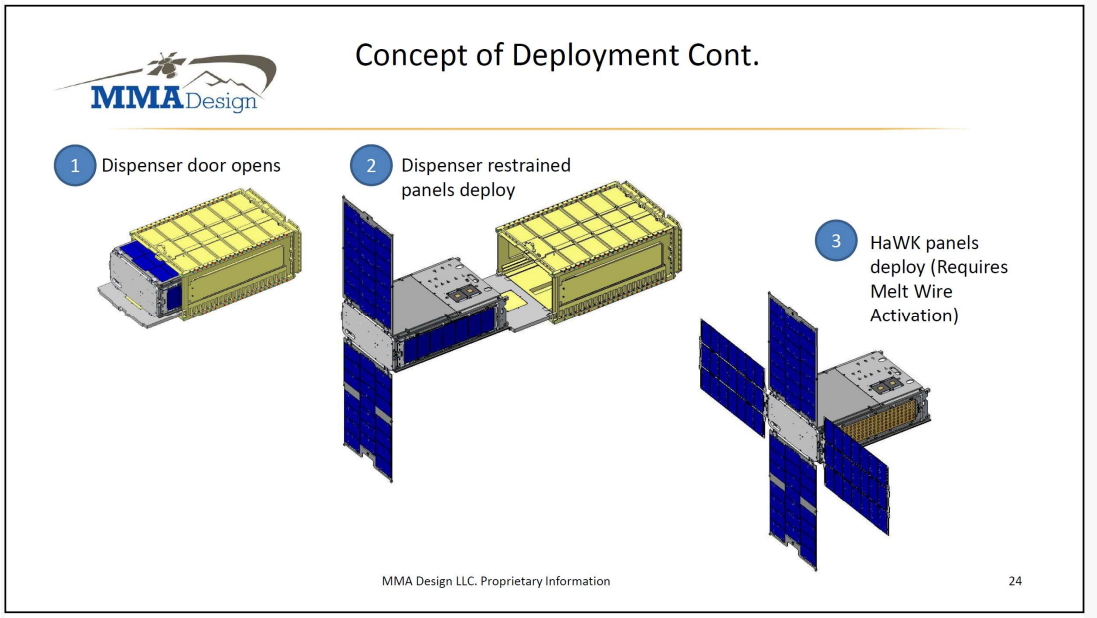




Artemis 1

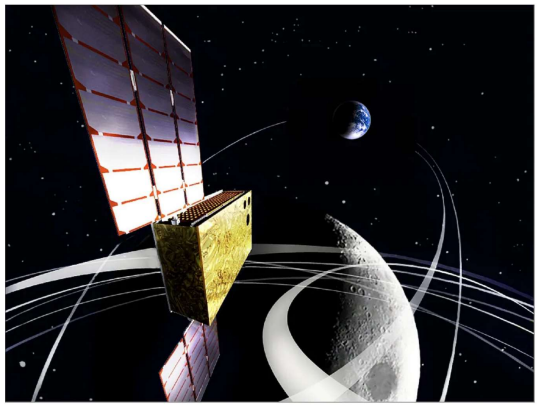
BioSentinel



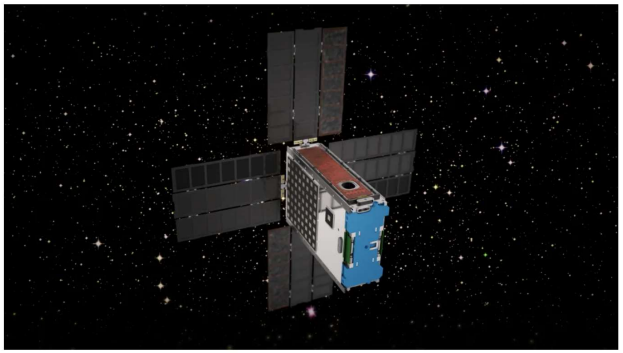


Artemis 1 CubeSats with MMA Arrays

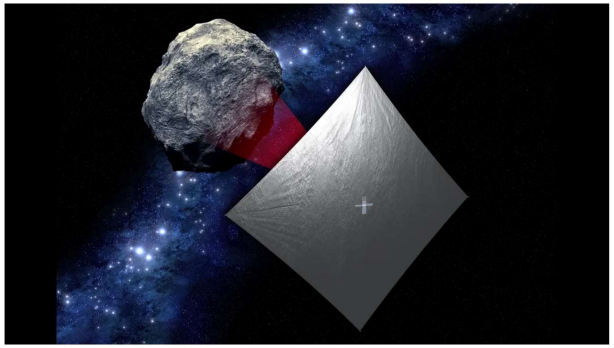
EQUULEUS



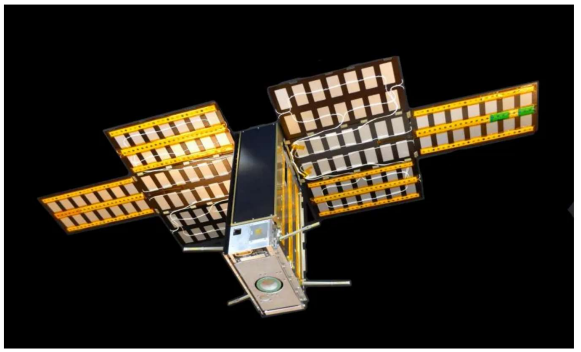
BIOSENTINEL



NEA SCOUT

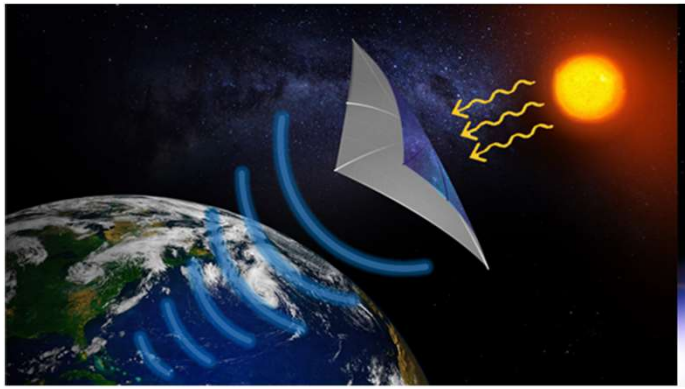


LUNAH-MAP

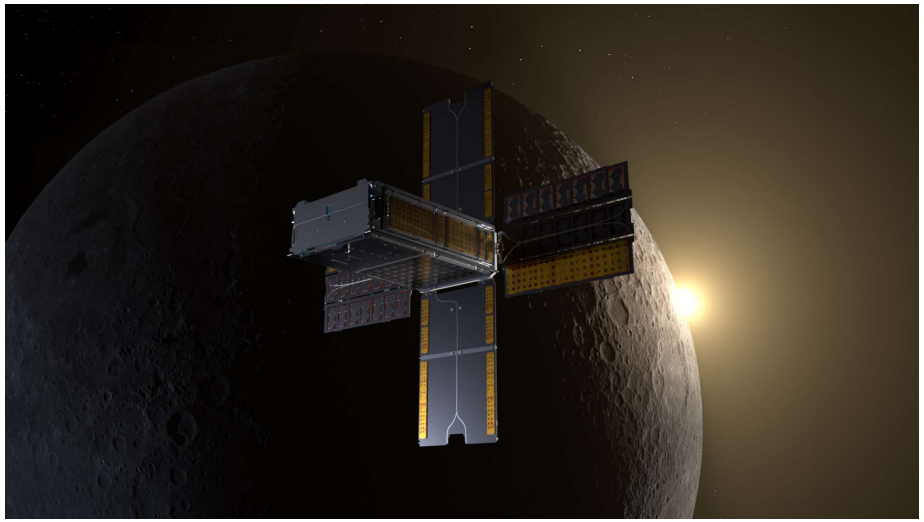


SSPIDR/ARACHNE

SPACE SOLAR POWER INCREMENTAL DEMONSTRATIONS AND RESEARCH PROJECT (SSPIDR)

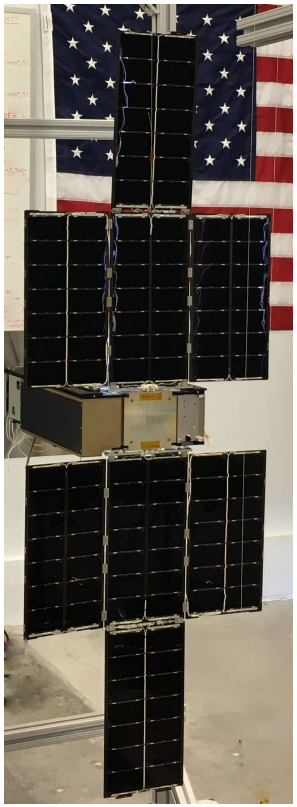


BioSentinel



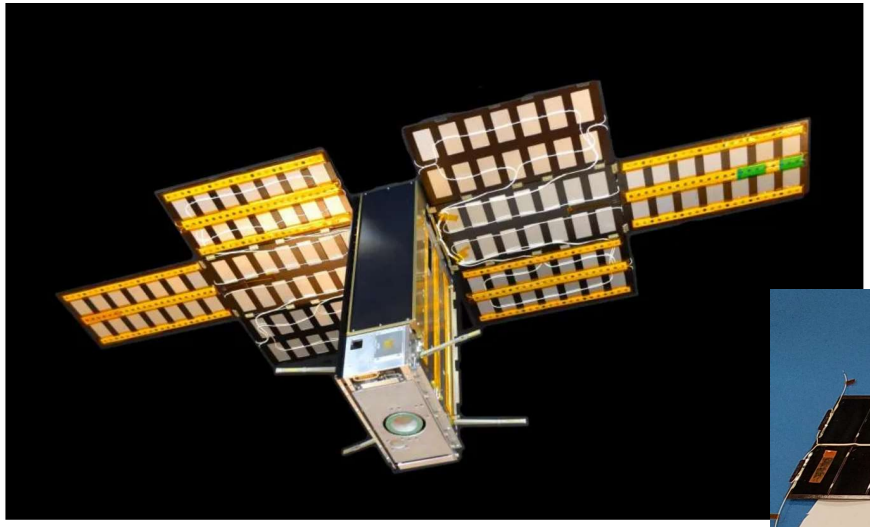
Mission:
Study impacts of space radiation near Moon on yeast microorganisms

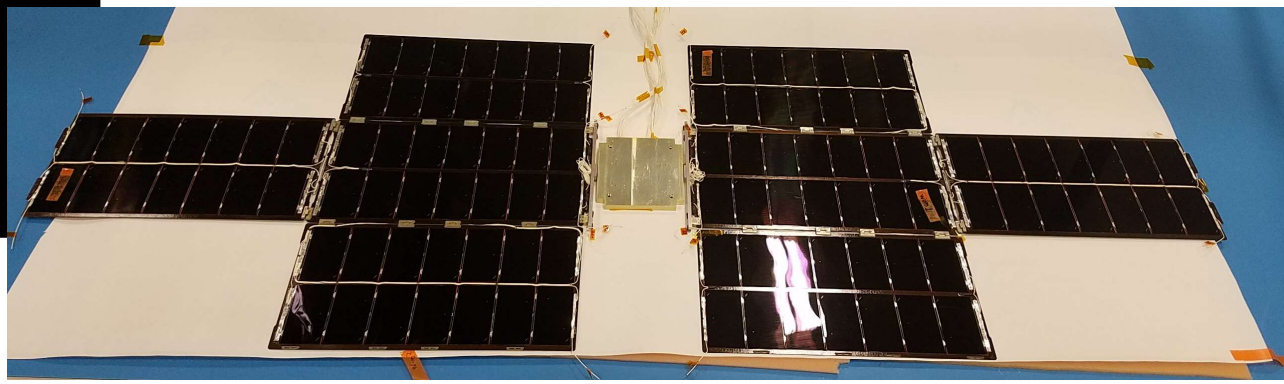
HaWK Arrays with Heritage SADAs



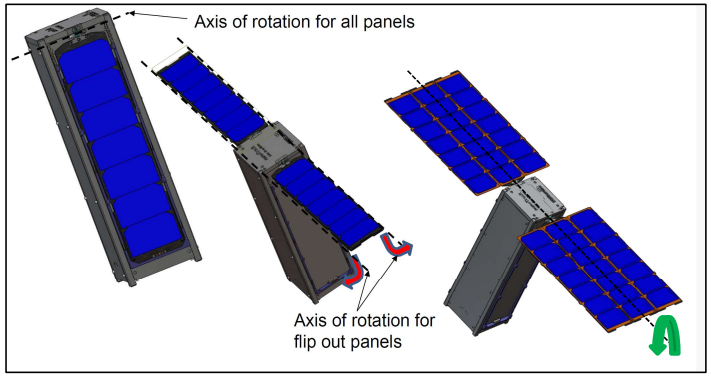
LUNAH-MAP
Wing and SADA Shipset

LUNAH-MAP

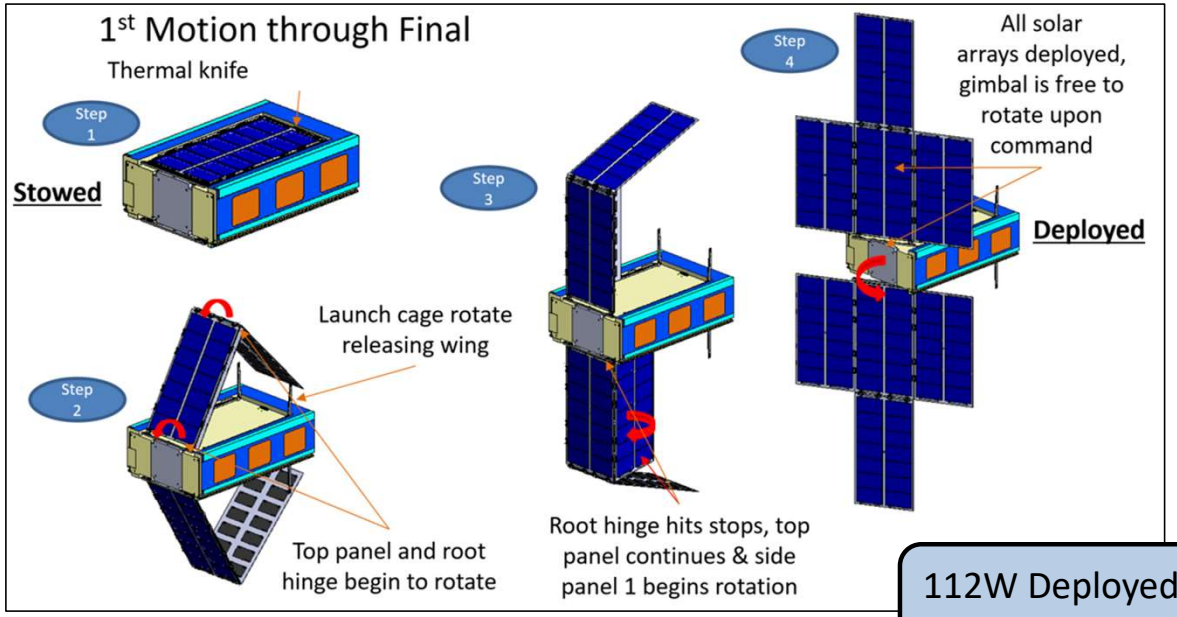




Deployment Sequence



42W Deployed
Array
(2 Wings)



112W Deployed
(2 Wings)

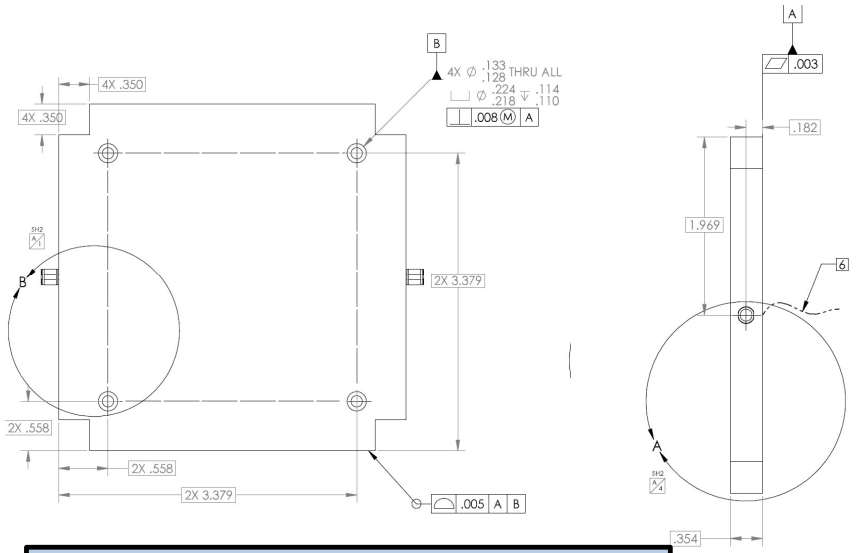
V2.0 Improvements

- FPGA Electronics
  - Rad-hard parts
  - Rad-tolerant parts available as a lower cost option
- Improved wing mechanical interface
- Improved/increased software functionalities
  - Readily programmable acceleration
  - Stepper motor full or half-stepping mode options

SADA Comparison

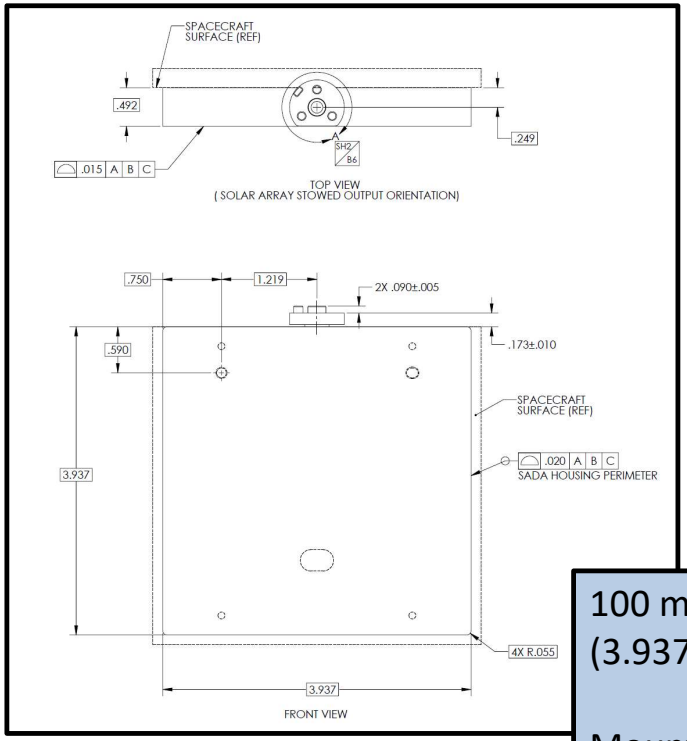
Category	V1	V2
Hardware, radiation tolerance	Not radiation tolerant	All ICs are rad-hard (microcontroller, FRAM)
Hardware, H-Bridge Circuitry	No Flyback Diodes	Flyback Diodes
Firmware, Error Reporting	None, no acknowledgment of sent commands	Extensive error reporting; ex: Unexpected limit switch triggers to indicate stall, reboot, invalid command sent
Firmware, Acceleration	None	Variable acceleration per user input, built in backlash region -- motor runs at slow speed through backlash before accelerating to final velocity
Firmware, Safety Limits	None	Backlash region during acceleration, limit on steps that can be travelled in one direction while homing, motor backs off limit switch once triggered to prevent excessive loading of the limit switch
Firmware, Drive Modes	Full Stepping	Full Stepping, Half Stepping (Lower power, lower torque, smoother operation)

Original and V2.0 Design



100 mm x 100 mm x 9 mm
(3.937 in x 3.937 in x 0.354 in)

Bonded Interface to Yoke

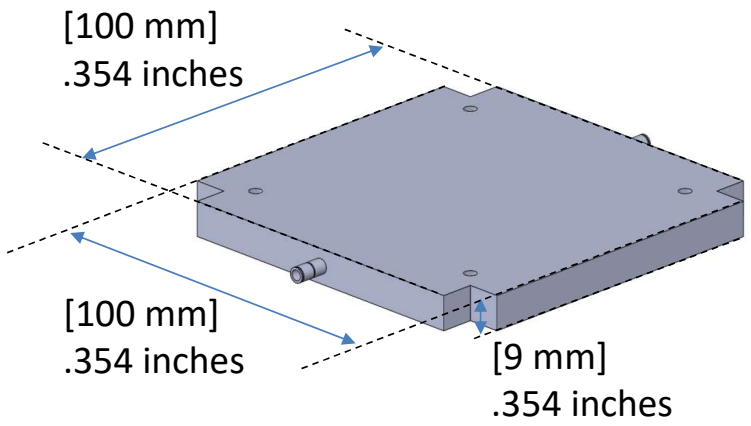


100 mm x 100 mm x 12.5 mm
(3.937 in x 3.937 in x 0.492 in)

Mounting Flange

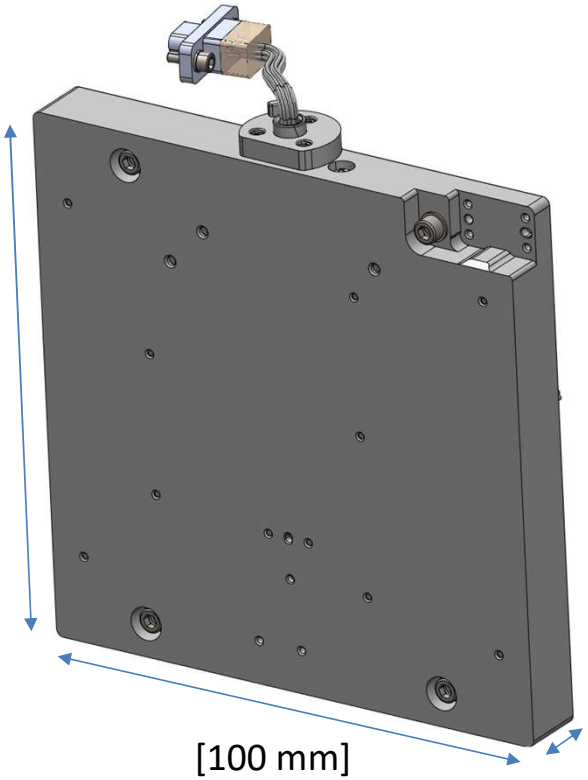
Solar Array Drive Assembly (v1.0)

- Voltage: 5 +/-0.1 V
- Current: ~500 mAmp
- Velocity: 1 rpm max
- RS-422
- 9 mm thick housing



New SADA (v2.0)

Outboard Side

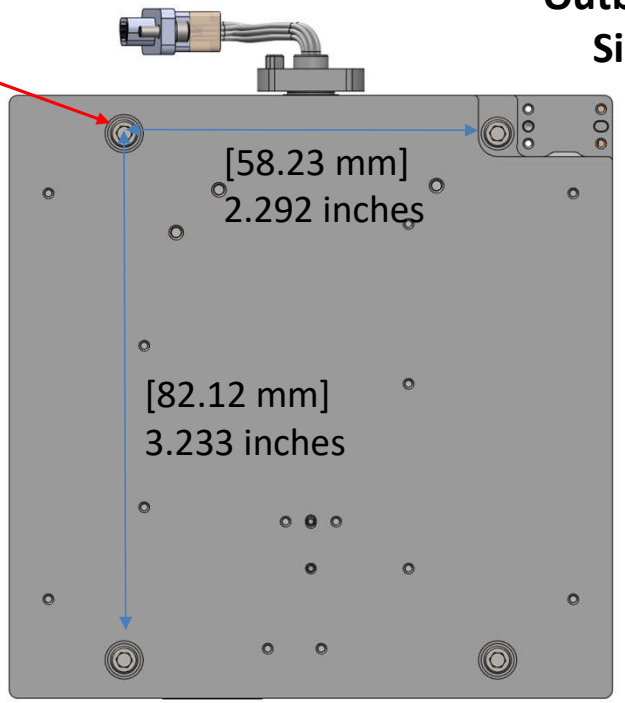


[100 mm]
3.937 inches

[100 mm]
3.937 inches

[12.50 mm]
.492 inches

4X #4 Mounting Screws



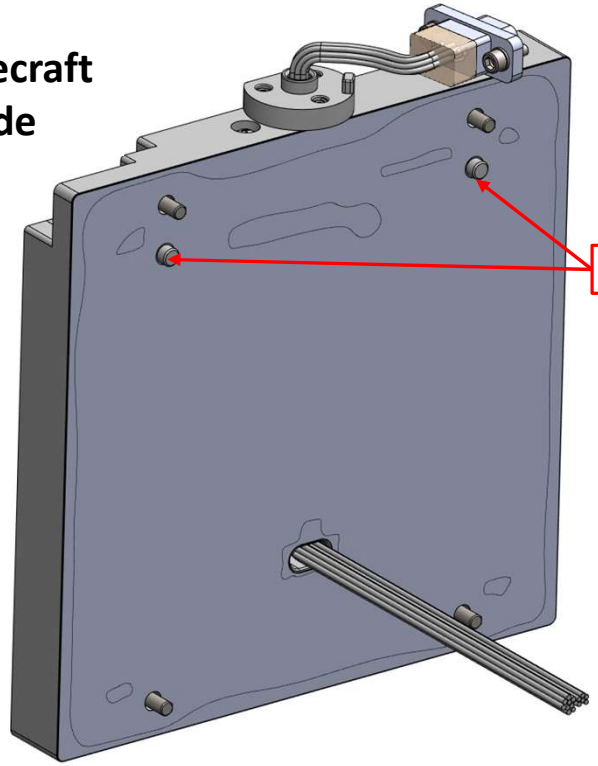
[58.23 mm]
2.292 inches

[82.12 mm]
3.233 inches

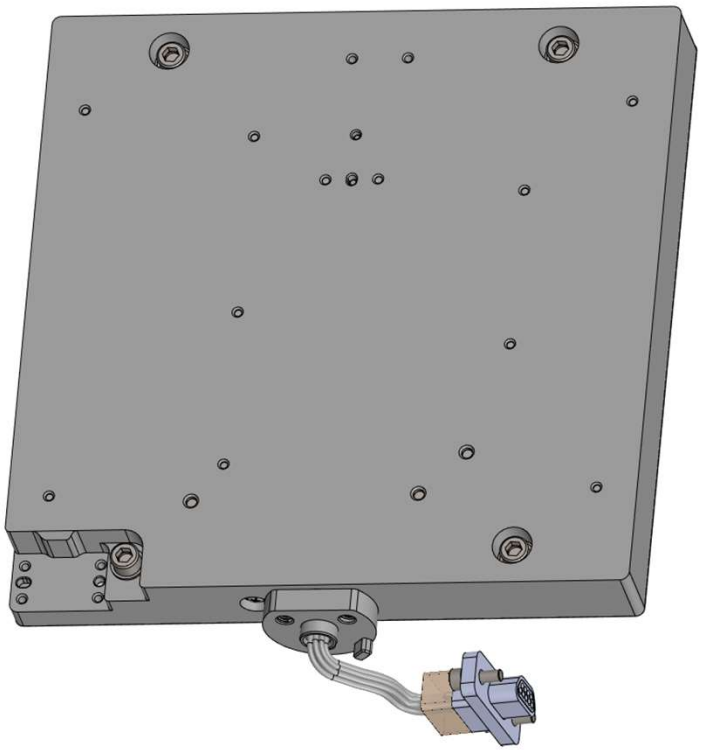
Outboard Side

SADA v2.0

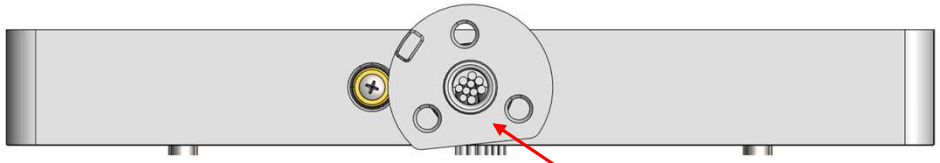
Spacecraft Side



Outboard Side

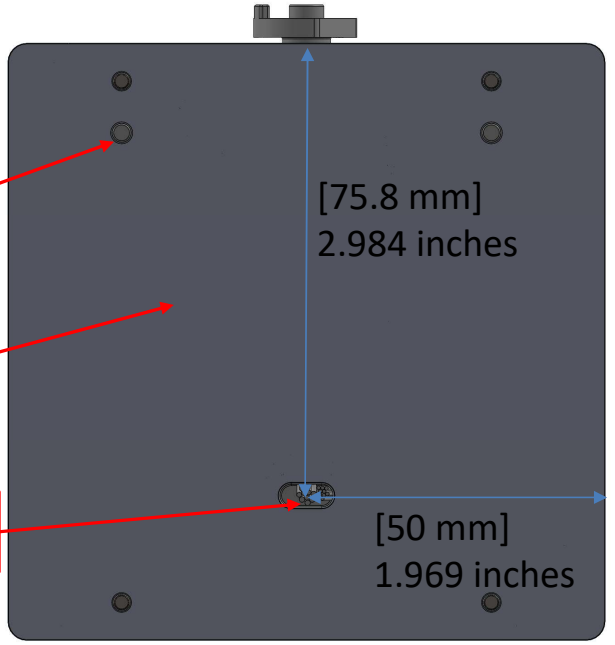


SADA v2.0



Mounting Interface to Wing

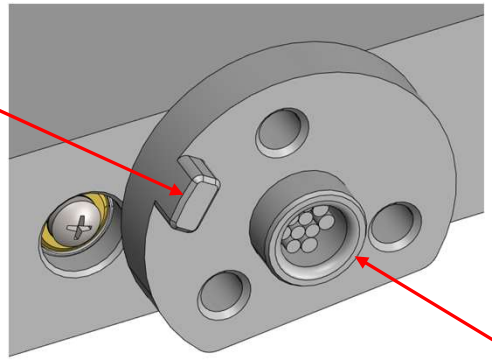
Locating Boss/Pins



Bonded Dust Cover

Array & SADA Wire Egress Location

Clocking Feature

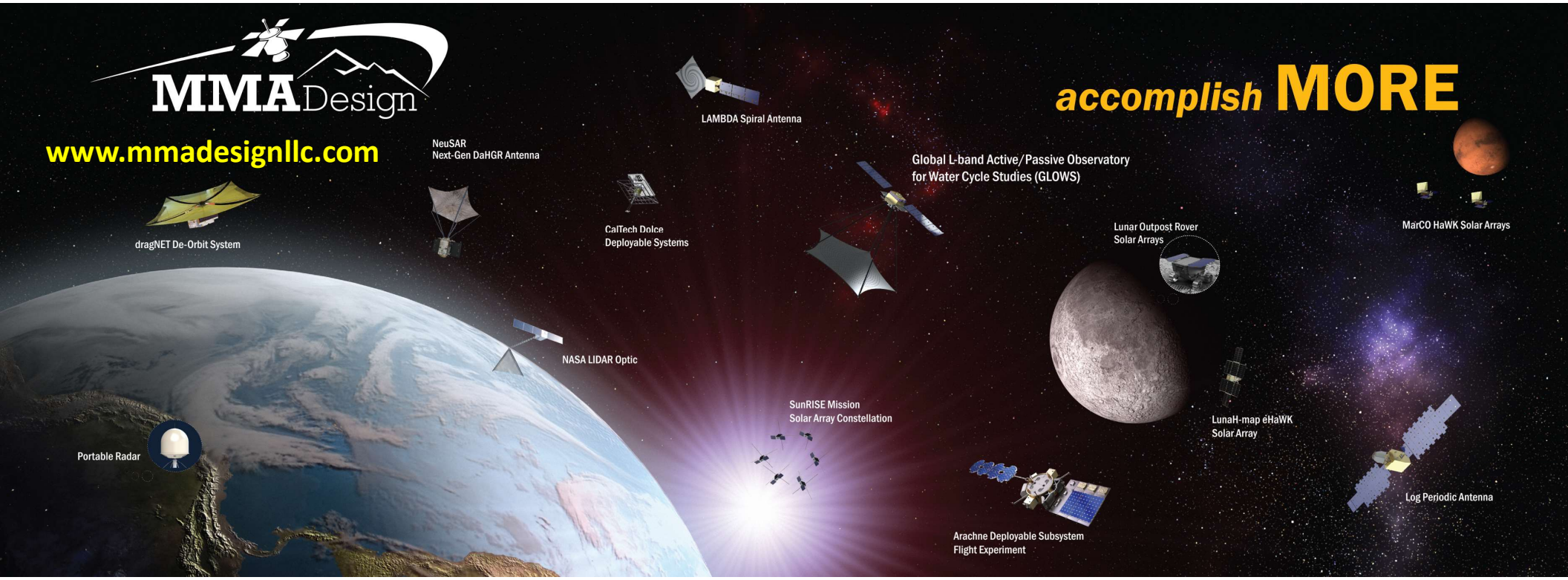


Axial Locating Feature

Comparison of Assemblies

Housing Thickness	Output	Maximum Wing Size (deployed mass)	Motor Torque Rating (not output torque)
7 mm	Dual (Single optional)	259 grams (2 wings)	5 in-oz
9 mm	Dual (Single Optional)	765 grams (2 wings)	17 in-oz
12.5 mm	Single (Dual Optional)	1,100 grams (1 wing)	28 in-oz

V2.0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dragNET De-Orbit System
CalTech Dolce
Deployable Systems
Lunar Outpost Rover
Solar Arrays
MarCO HaWK Solar Arrays
NASA LIDAR Optic
SunRISE Mission
Solar Array Constellation
LunaH-map eHaWK
Solar Array
Portable Radar
Log Periodic Antenna
Arachne Deployable Subsystem
Flight Experiment

Thank You!