



MMA Design LLC High Watts per Kilogram (HaWK) Solar Array Series

April 2014



www.mmadesignllc.com



MMA Design Overview



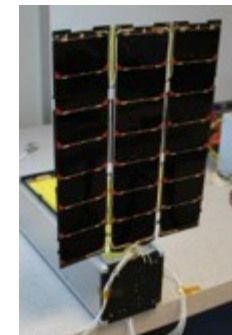
- Facilities in Boulder County Colorado
 - Engineering, Test and Machine shop Boulder office
 - Engineering & Prototyping at Nederland office
- Business Areas
 - Deployable Apertures and Structures
 - Solar Array Systems
 - Deployable antennas
- Products
 - dragNET De-orbit Modules
 - HaWK High Performance Solar Arrays
 - MMA Modular Bus
 - ESPA-Class Modular Solar Array
 - CubeSat Gimbals



MMA De-orbit System



FalconSat-7 CubeSat Deployable Aperture

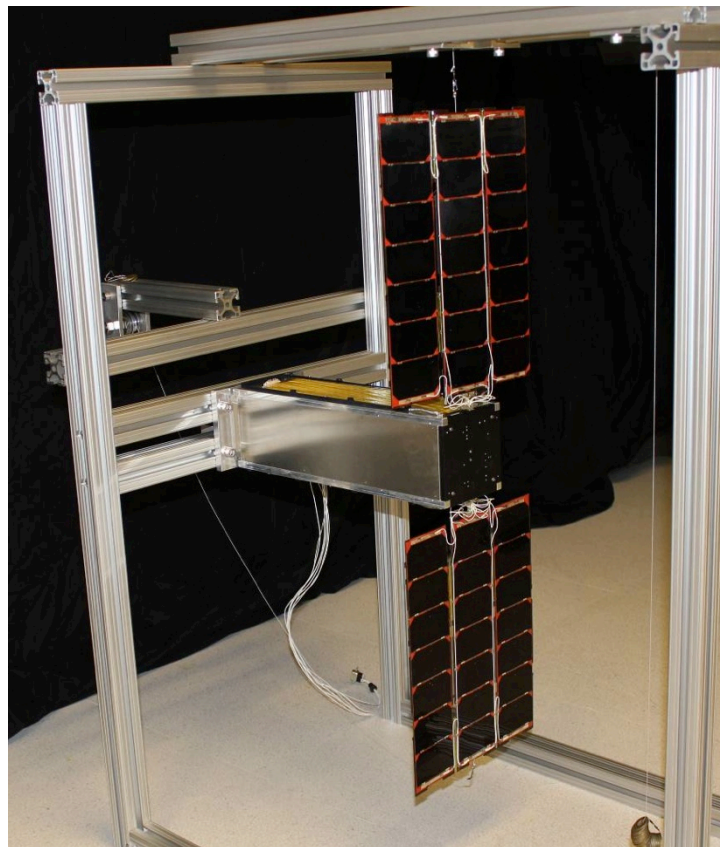


HaWK CubeSat Solar Array





MMA Design LLC CubeSat Solar Array Series



April 2014



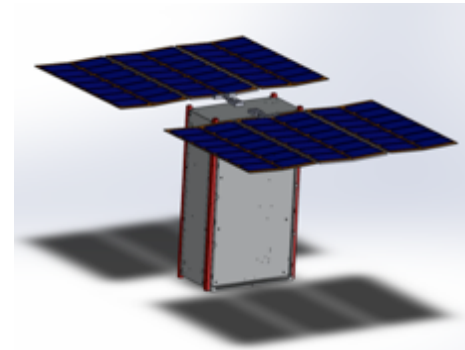
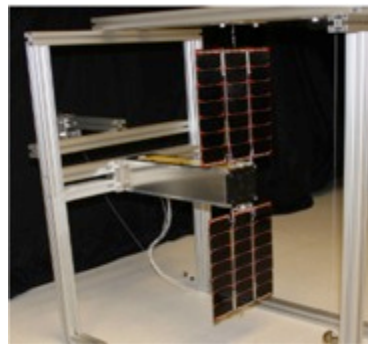
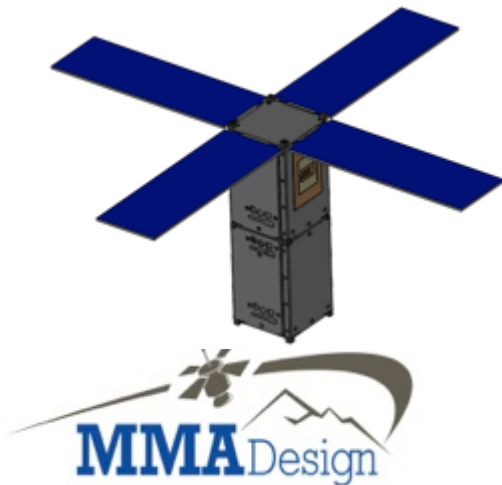
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Cubesat Solar Array Configuration Vs. Hawk Solar Array Series



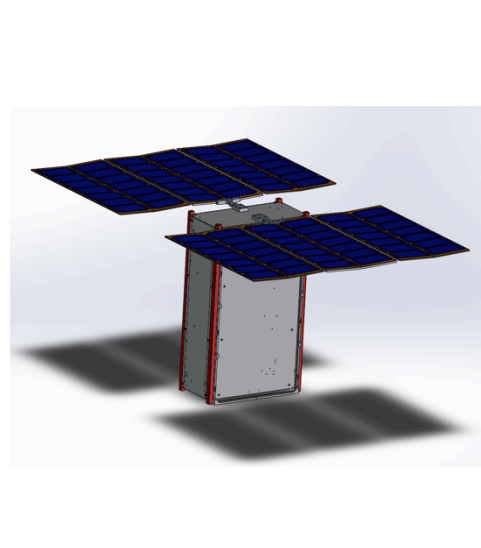
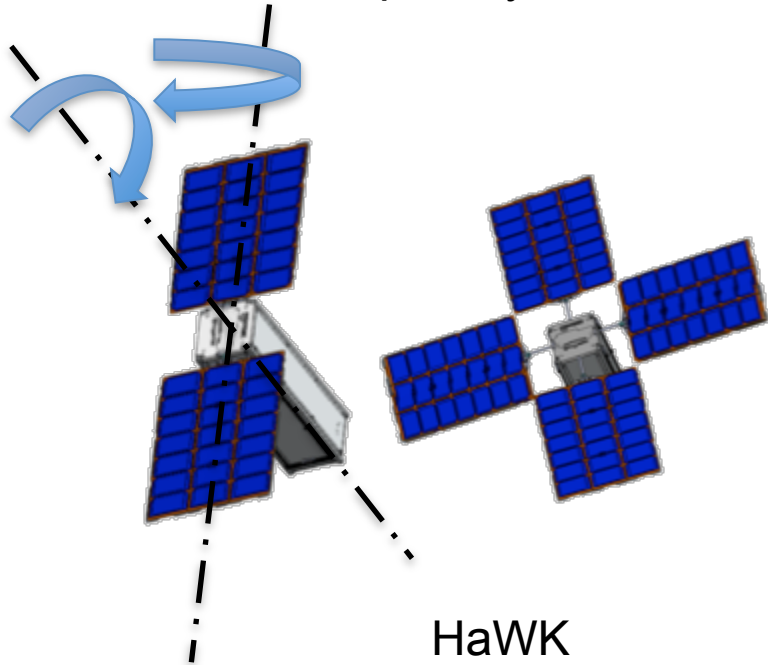
Typical CubeSat	HaWK Solar Array	E-HaWK Solar Array
No Sun Tracking	Ability to Sun Track	Ability to Sun Track
	Trickle charge in case of tumbling	Trickle charge in case of tumbling
Body Mounted or Conventional Deployed	Stows in the unused space between the P-Pod and CubeSat	Stows in the unused space between the dispenser and the CubeSat bus
60 W/kg	130 W/kg (>200% increase)	130 W/kg
21 W Peak Power	36 W Peak Power	72 W Peak Power
5 W OAP	22 W OAP (>300% increase)	44 W OAP



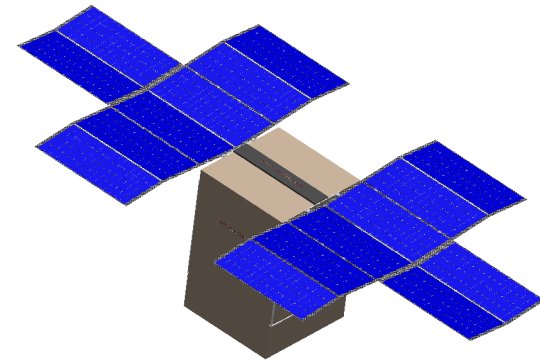


HaWK Series Variations

- HaWK array is a **modular high performance solar array**
 - HaWK can be configured for peak power from 6W to 650W utilizing Spectrolab UTJ's
 - Gimbal capability in one or two axis



E-HaWK



ESPA Configuration

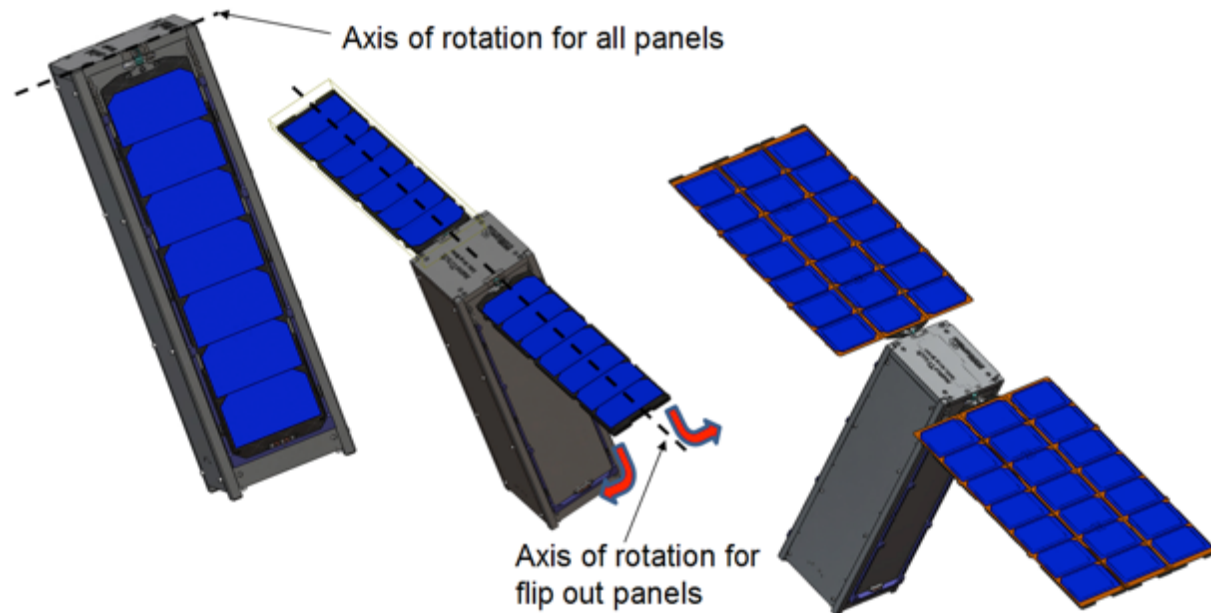
Examples of HaWK Series Variations





HaWK Deployment Sequence

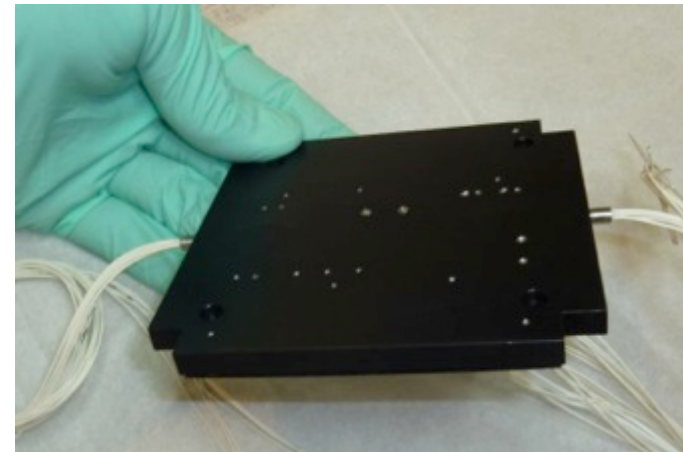
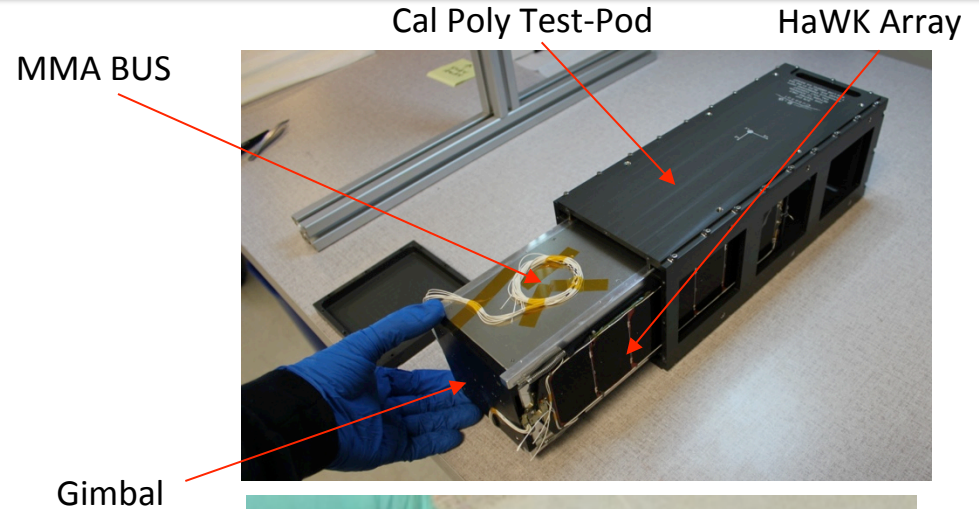
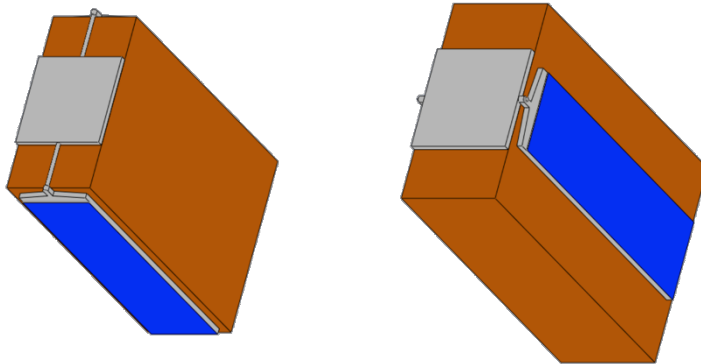
- Initiate launch release, simple heater circuit power
- Root springs rotate center panel
- Spring pre-loaded Flip-out side panels unfold
- Deployed state reached at hinge hard stop
- Enable and command SADA to articulate in sun tracking mode





CubeSat HaWK Packaging

- Uses available 6.5 mm space between P-Pod and CubeSat
- Gimbal is 6.5 mm thick and fits within the 1U unused space on the end of the CubeSat



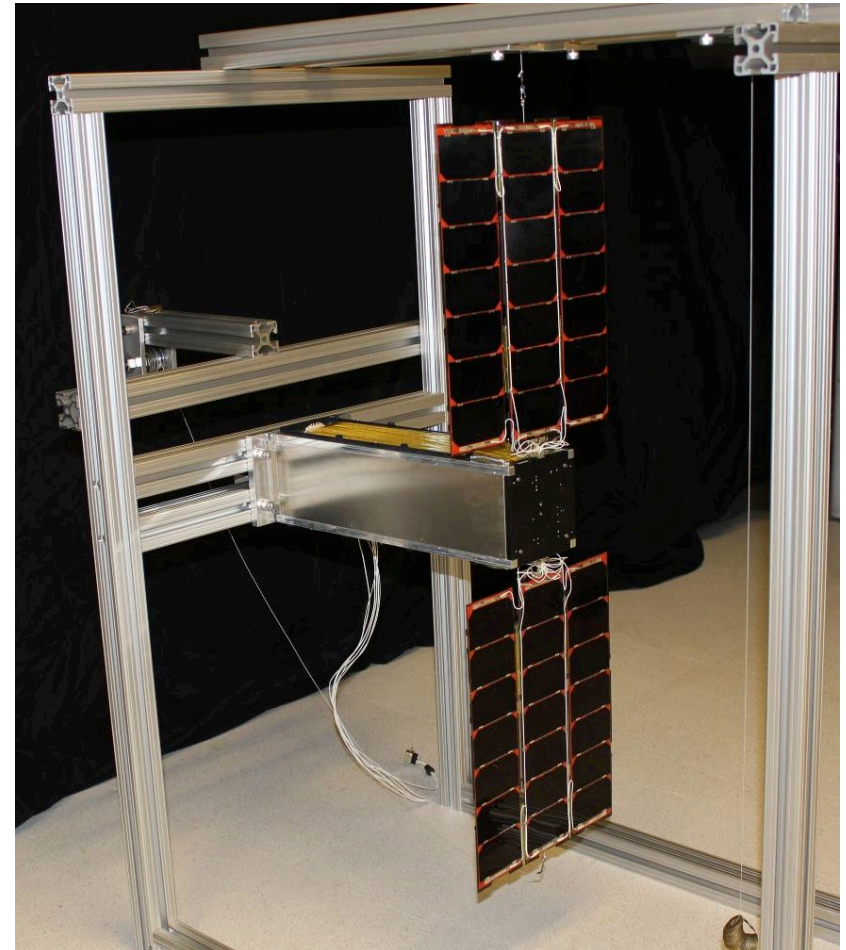
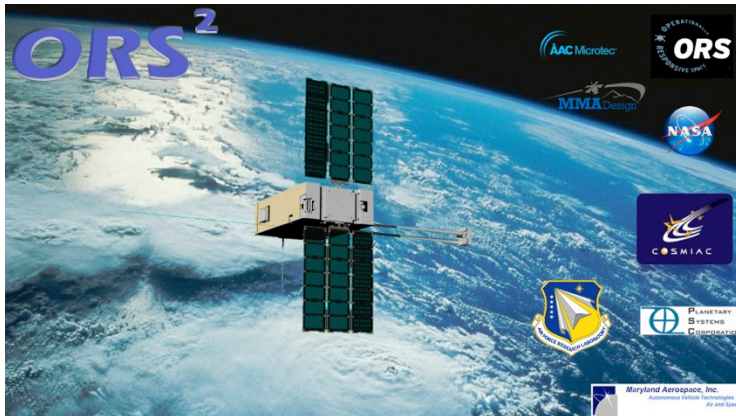
HaWK SADA Flight Unit



ORS HaWK Protoflight Unit



- ORS unit is a HaWK
- Graphite panels
- Single axis gimbal
- Spectrolab UTJ CICs
 - Welded interconnects
- High Stiffness deployed structure > 1.5 Hz

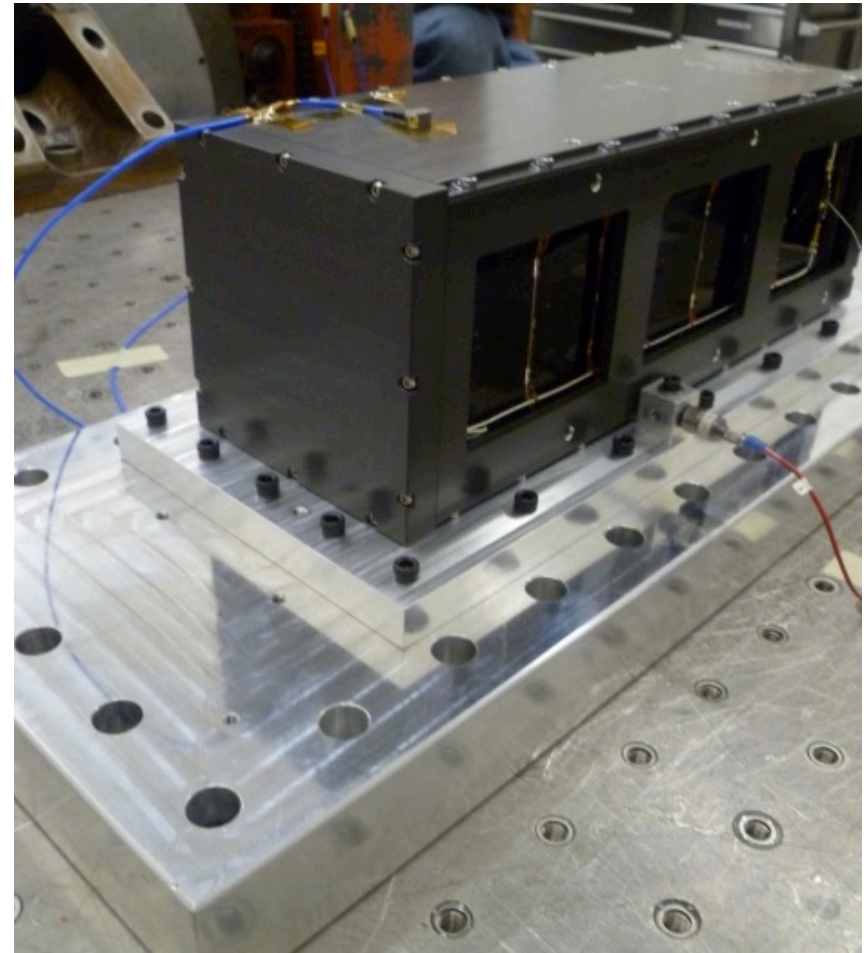




ORS Hardware TRL 8

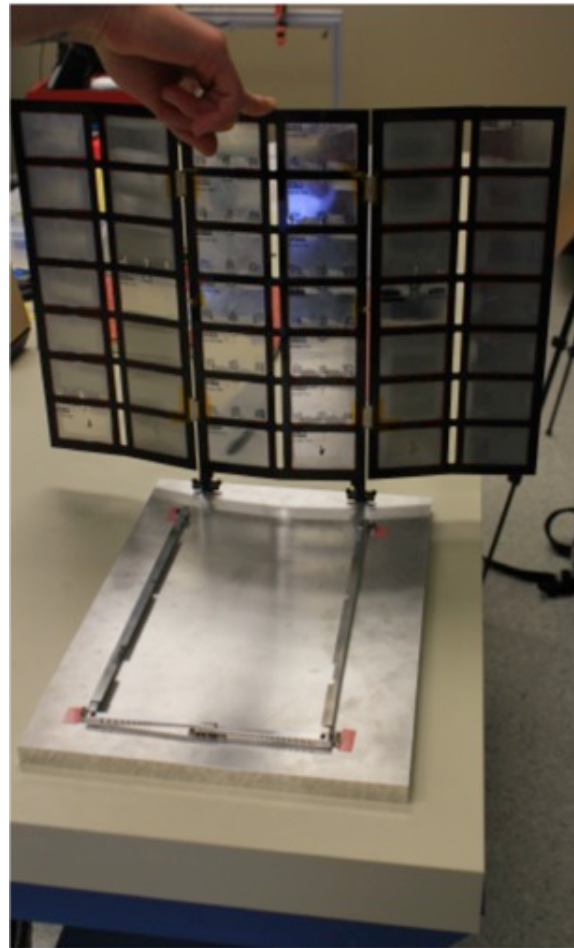


- Thermal and vibration testing has been preformed on EDU
- Protoqual unit built
- Testing is complete
- Flight Heritage Fall 2014





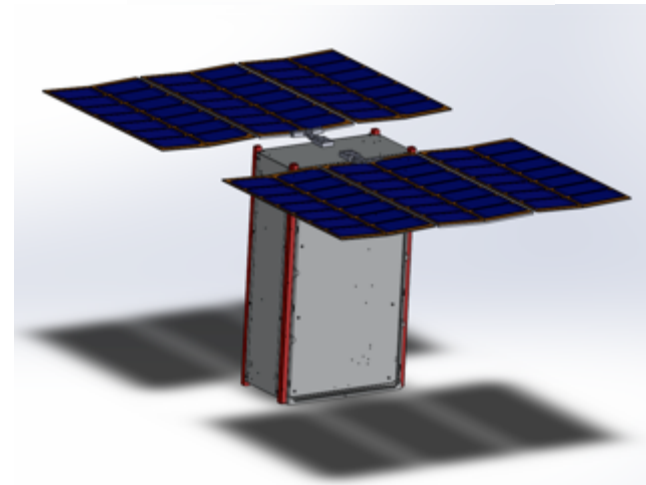
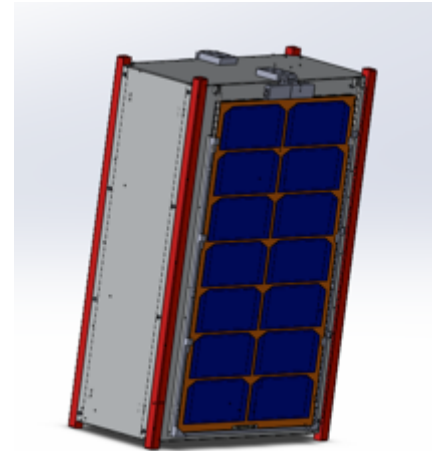
E-HaWK Solar Array





6U E-HaWK Configuration

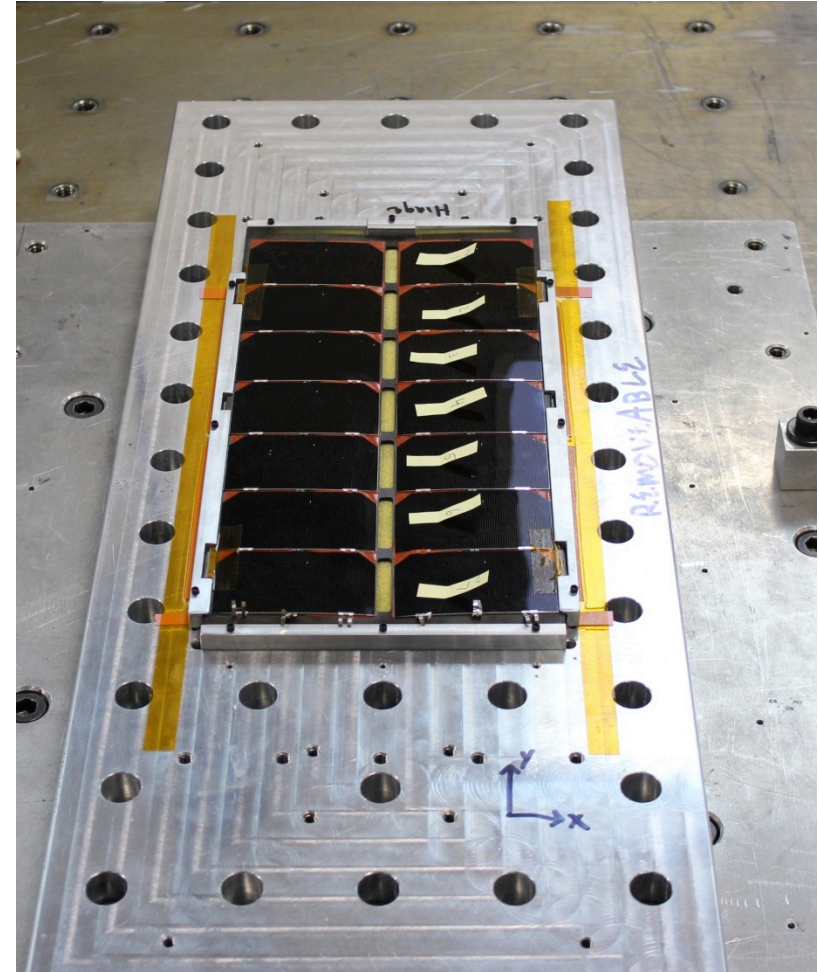
- Performance
 - Maximizes volume and mass for payloads
 - 120 W/kg
 - 72W Peak Power
 - 44W OAP
 - ~0.6 kg array and launch restraint system
 - Specific volume ~250 kW/m³
- E-HaWK Features
 - Complete system including launch restraint
 - Melt rod wire HDRM
 - Two-wing solar array
 - Compatible with multiple cell technologies
 - Spring deployed/undamped
 - 2 rigid center panels
 - 4 flip out panels





E HaWK Risk Reduction

- Vibe testing was completed on a stowed wing.
- Multiple vibe profiles were run:
 - ESPA RUG Qual
 - Goddard 7000
- These represent the most stringent profiles the wing could possibly be exposed to
- Overall the wing was exposed to a max of 16.1 GRMS, and tested in each axis for 4 minutes





Conclusion

- HaWK establishes State of the Art performance
 - Efficient packaging
 - Sun tracking
 - High Specific power
- Technical Readiness Level 8
- Flight Heritage Fall 2014
- Space Act Agreement with NASA to apply to future NASA missions

