MMA Design

accomplish **MORE**

our MISSION

Space is our passion, and exploring is in our DNA.

MMA's innovative, talented and agile team is excited about creating deployable solutions that enable your challenging space and terrestrial missions. Our research and development leads to the commercialization of revolutionary products.

Through **Solutions, Exploration, Excellence** and **Disruption** (**SEED**s), we aim to enhance and preserve our way of life for many generations to come.

our CAPABILITIES

We often help our customers define their requirements. Our heritage, expertise and broad capabilities allow us to be as lean or as rigorous as the mission requires. Our culture of enterprise and invention is balanced by established and proven processes. We know what differentiates us is our ability to be agile while at the same time delivering high-reliability solutions that retire risk... and sometimes embrace it. Like all of our innovative solutions, each mission is unique and requires a unique approach.

Engineering Design + Consulting

Research + Development

Functional Testing

Vibe + Shock Testing

Analysis

Manufacturing + Fabrication

Thermal Testing

RF Testing

driven by VALUES

You have probably heard us declare:

Space is our passion, and exploring is in our DNA.

Indeed, our values drive everything we do. Through Solutions, Excellence, Exploration and Disruption (SEEDs) we aim to enhance and preserve our way of life every day, with every program, for many generations to come. To achieve this lofty aspiration we put PEOPLE FIRST and say YES to hard things.

The challenging problems with which our customers come to us are no match for our creative, agile, high-performing teams who are passionate in the belief that innovation is vital to advancing new space technologies.

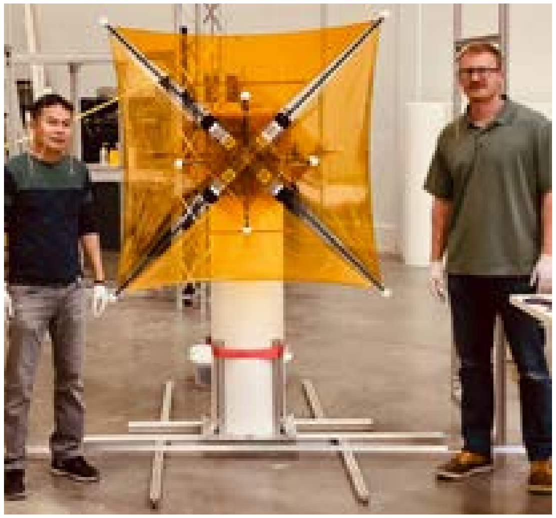
We are in the business of forging relationships and breathing life into ideas. The solutions we bring to market have a positive impact in the world, and we firmly believe that our small company makes a HUGE difference.

Since 2007, MMA has been leading the SmallSat revolution. And our customers agree that our team consistently exceeds expectations when it comes to results, quality, process and overall customer experience.

We help our customers accomplish MORE with less. But don't just take our word for it, keep reading to learn exactly how we have delivered more innovation, more capability and more success with each new mission.

powered by VISION

changing THE GAME



MMA teams pose with the T-DaHGR above and P-DaHGR below.

MMA's Broad Range of Antenna Architectures are Revolutionizing Communications and RF Sensor Capabilities for Military and Commercial Enterprises

It all started with our research and development of the dragNET de-orbit system membranes. Understanding how to effectively stow and tension this lightweight and flexible substrate into a small package, like we did on de-orbit, inspired us to reimagine how this capability might be used to enable very large apertures without the mass or volume typically required.

We were also experimenting with antenna payloads and different, novel ways to deploy and control them. In 2013, we developed and built a large, deployable UHF space-based antenna as well as an antenna pointing mechanism that controlled the oriention of an array of antennas — the Spine APM, or ganged array.

The Deployable High-Gain Reflectarray "DaHGR" Antennas were inspired by this experimentation and discovery, and sparked our development of antenna payloads, and the world of capabilities they could open up for our customers. MMA originally envisioned two unique configurations, but the dramatic aperture packing density these enabled were so game-changing that many more architectures were naturally spawned. The T-DaHGR, or Tape-Deployable High-Gain Reflectarray, uses tape springs to tension the membranes and react structural loads. This large, spacefed reflectarray enables large apertures with low deployed inertia, and can be configured to support wider bandwidth than traditional reflectarrays.

Similarly, the P-DaHGR, or Pantograph-Deployable High-Gain Reflectarray, uses the same lightweight, flexible membranes but tension is created using a pantograph hoop. Decoupling the membrane tension from the structural loads enables a smaller stowed envelope at the expense of higher deployed inertia compared to T-DaHGR.

I have seen companies that are agile, and I have seen companies that are innovative. But I've never seen a company that is both. ***Until MMA.***

R3D2 Mission on orbit.
Rendering courtesy of Northrop Grumman.

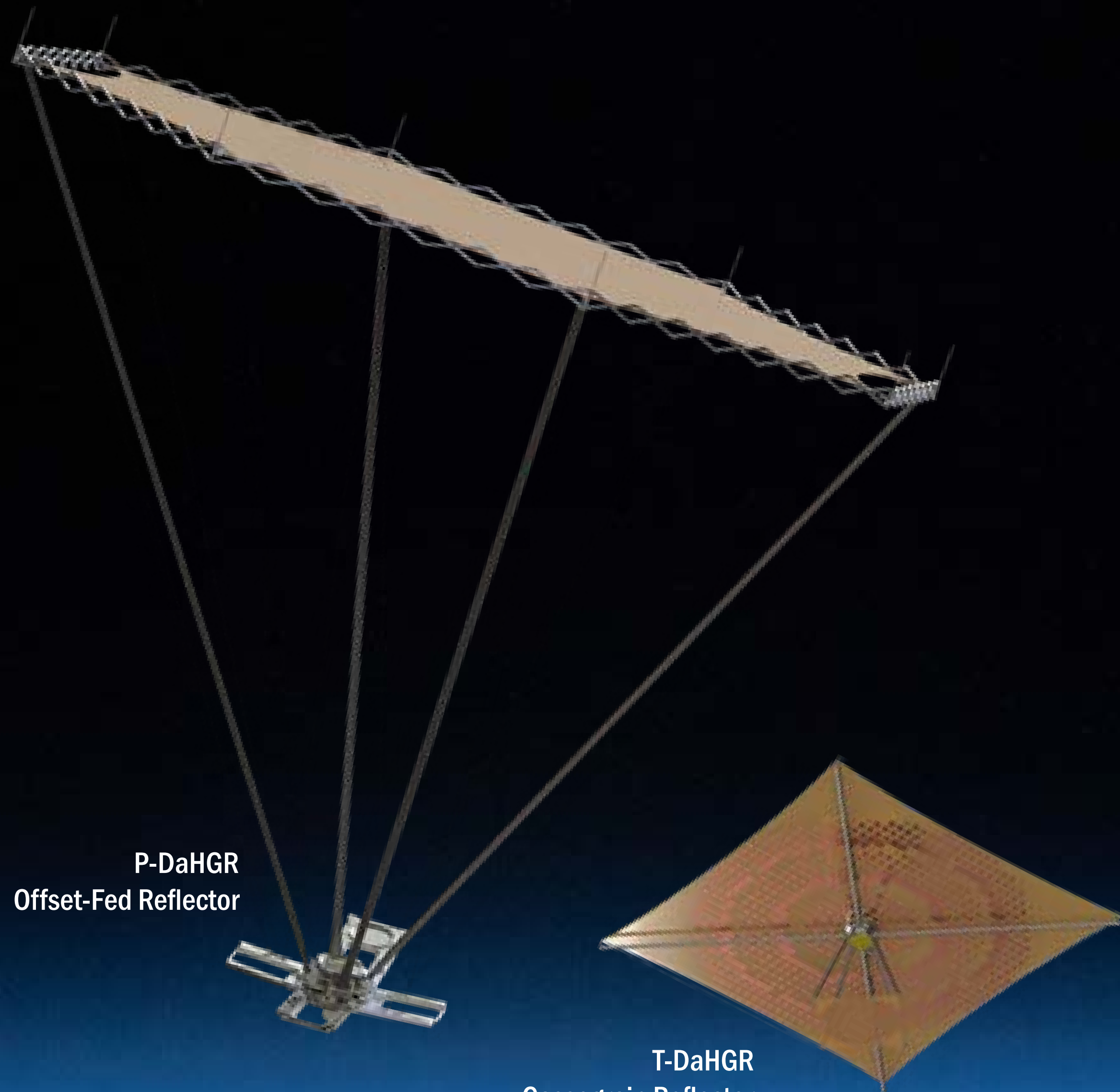
The DaHGR antenna provides performance equivalent to a conventional parabolic antenna with significant advantages in compaction, simplicity, scalability, and cost for narrow-band or multi-band applications.

An antenna's aperture and the power you have on a satellite dictates the size of the antenna you need on the ground to receive information. In short, the larger the antenna is in space, the smaller the antenna can be on the ground, a detail critical for our military in remote locations. Additionally, packaging an antenna efficiently for launch allows you to leverage smaller launch vehicles than you normally would with larger satellites.

But of course, each mission is unique, with unique spacecraft, mission requirements and other constraints and considerations. Applying our learnings and broad expertise, enabled by the building blocks in our technology toolkit, we have created an expansive range of antenna architectures and configurations which can be scaled up or down, and applied to address unique mission challenges.

The architectures we have designed — and those we have yet to conceive in support of our customers' unique needs — support a range of frequencies, spacecraft platforms, bandwidths, apertures, boast best-in-class packaging efficiencies, and support planar phased arrays and reflectarrays.

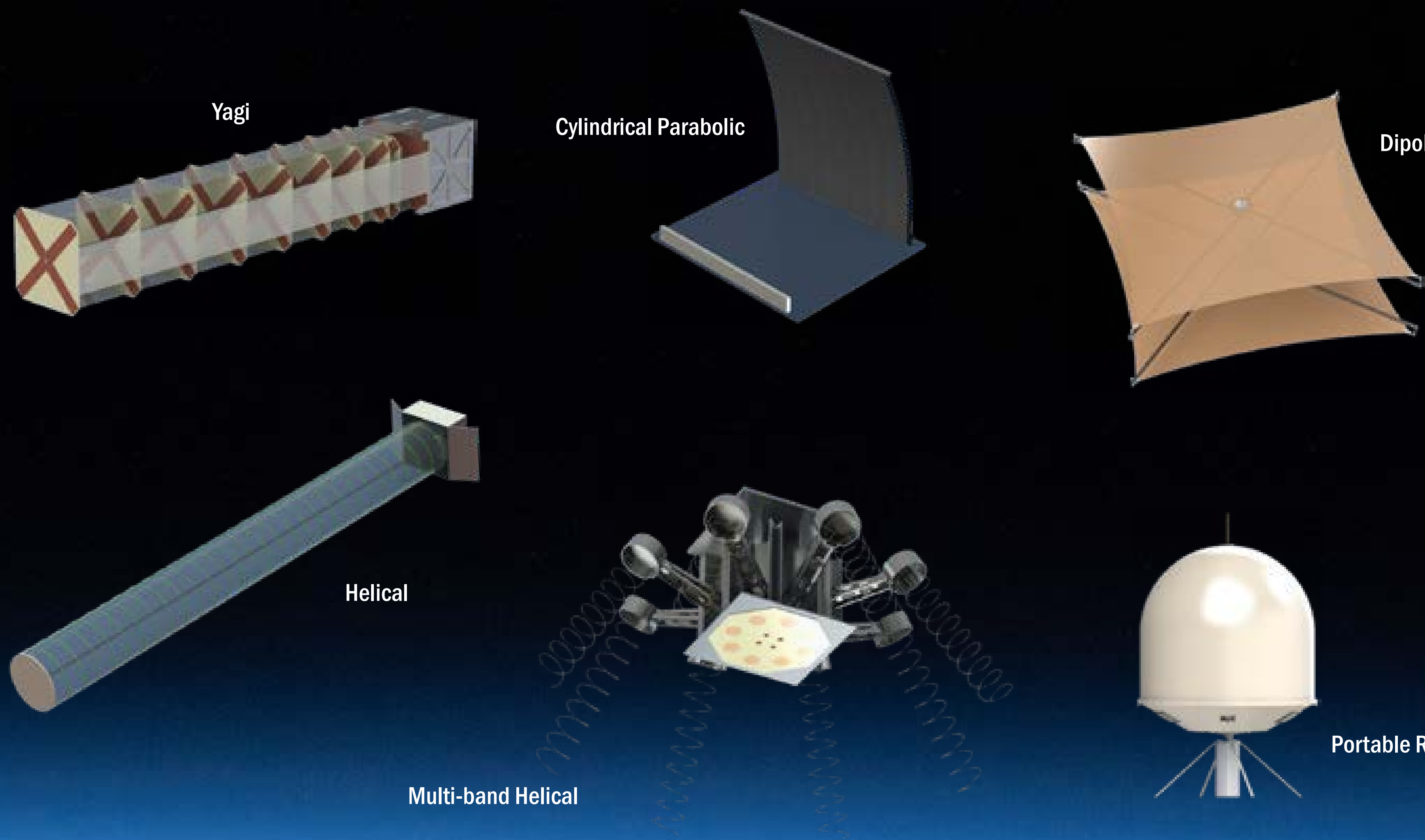
Passive
ANTENNA ARCHITECTURES*



*Patented

Active

SOME ANTENNA ARCHITECTURES*



*Patents Pending

HaWK Solar Arrays Deliver High Watts per Kilogram Crushing the State-of-the-Art

Powered by innovative packaging ideas, expertise in deployable mechanisms and with critical support from the Air Force Small Business Innovation Research/Small Business Technology Transfer Program, MMA put its team to solving the problem of how to efficiently power missions for the ever-growing CubeSat platform. Other companies were also developing solar array products for CubeSats, but it was MMA that led the way in this critical arena.

AI+T team doing a final inspection on HaWK solar arrays before shipping.

With the CubeSat platform, the fundamental challenge is packing everything into a highly constrained volume, thus most off-the-shelf solutions would not work. Producing adequate power is also a challenge because of the inherent size constraints and static placement of solar arrays on a CubeSat. Finally, maintaining payload capacity for sensors, radios and other key capabilities is critical for mission success.

MMA's HaWKs — deployable, semi-rigid-panel solar arrays, in which the panels fold over each other in a variety of configurations — are designed to maximize peak power for a given stowed envelope. They support higher performance by allowing small satellites to maintain greater power reserves while freeing the mission instruments to accomplish other objectives. Low-profile hinges and launch restraints allow the solar array to stow in a very thin package.

MMA's HaWK system can use any type of existing or future solar cell and stows in much smaller spaces than roll-out solar arrays, which typically require a flexible solar cell to be able to form a tight radius as they collapse for stowage. Moreover, the solid substrates used on HaWKs provide better radiation shielding than typical rollable substrates.

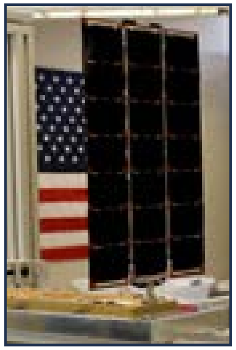
More power, more configurations, more heritage, more reliability, more capability, more breadth. MMA's solar arrays really lead the market in delivering ***MORE.***

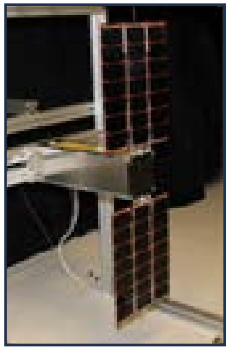
An artist's depiction of the twin CubeSats traveling over the red planet. Image courtesy of JPL.

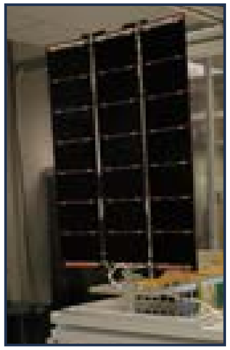
delivering MORE

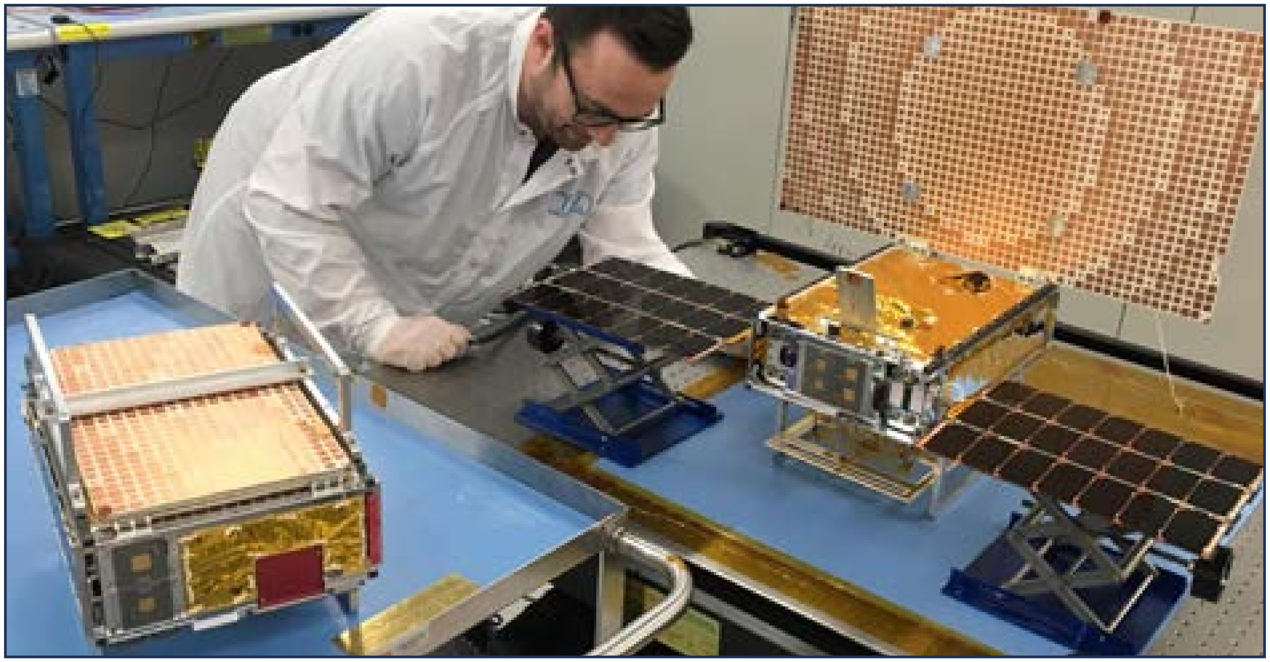
Delivering more kilowatts per cubic meter on myriad missions with a broad range of HaWK configurations has allowed us to lead the CubeSat market, and poises us for more success on larger platforms as our HaWK solutions scale.

The advantages of MMA's High Watts per Kilogram "HaWK" solar arrays are clear: innovative packaging and restraint schemes, highly modular architectures, customizable designs, and best-in-class performance metrics.

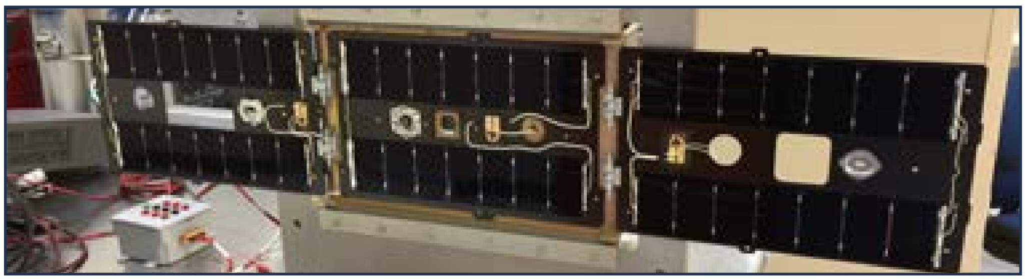
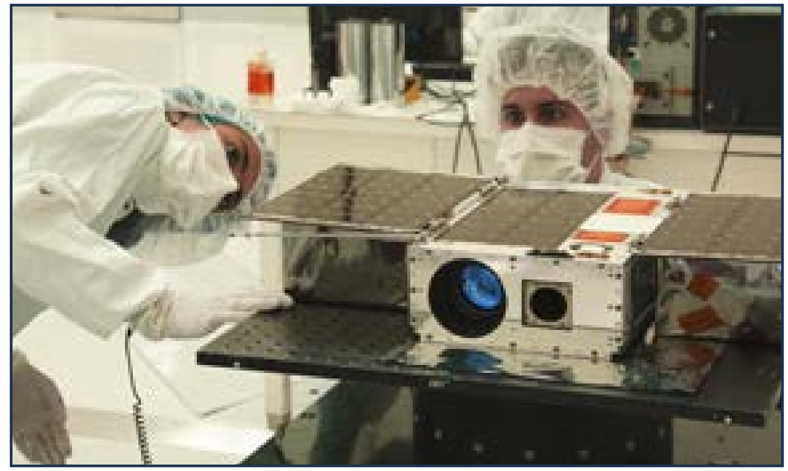




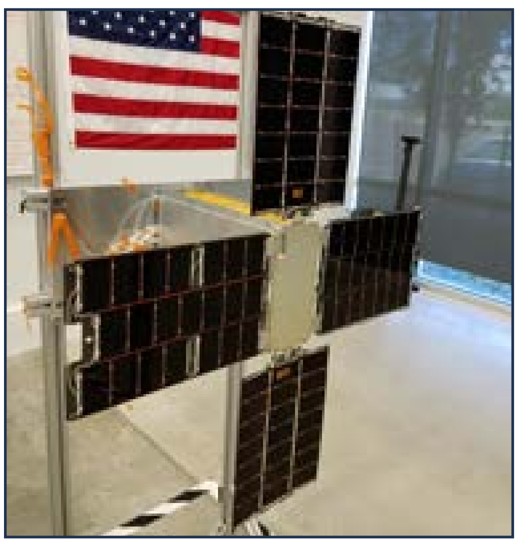


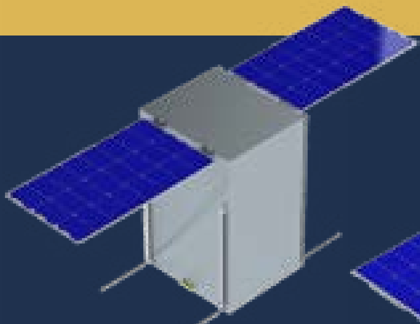


Top row, from left to right: AFRL SHARC, AFRL SPARC, AFRL HaWK, JPL LunarFlashlight, zHaWK
Bottom row, from left to right: Commercial HaWK, JPL MarCOs A and B

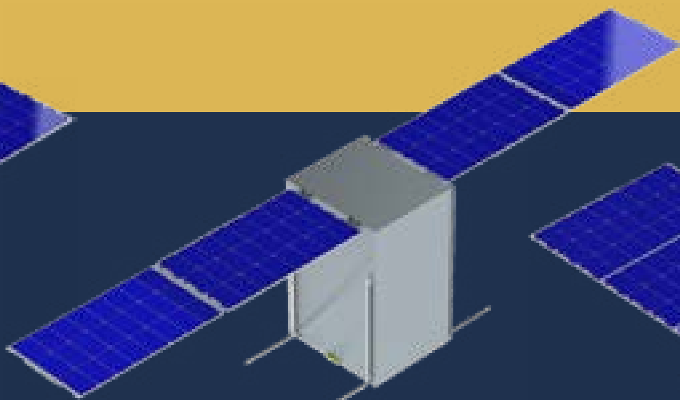




Clockwise from above: JPL ASTERIA, HaWK wing, ASU LunaH-map, AFRL eHaWK, NASA AMES BioSentinel, DoD HaWK, University of Tokyo EQUULEUS

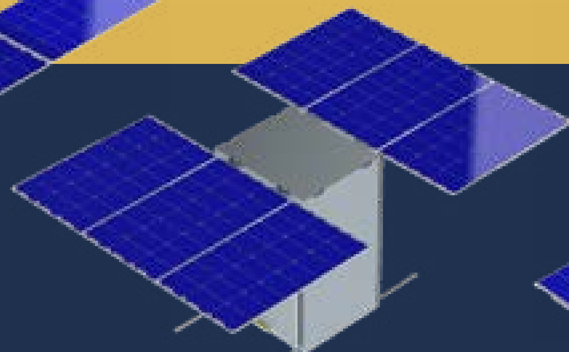


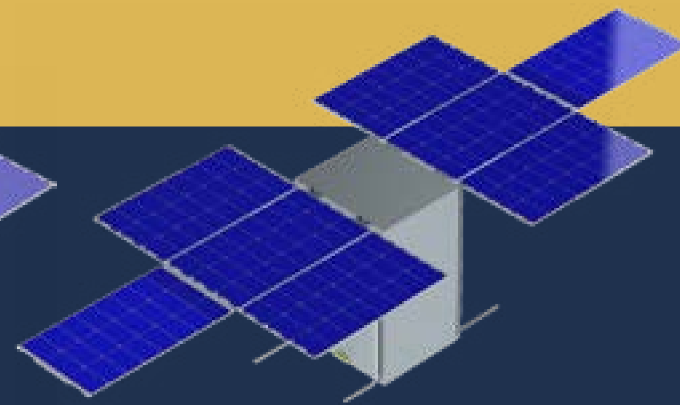
Single Panel
6U/12U: 48W
8U/16U: 59W



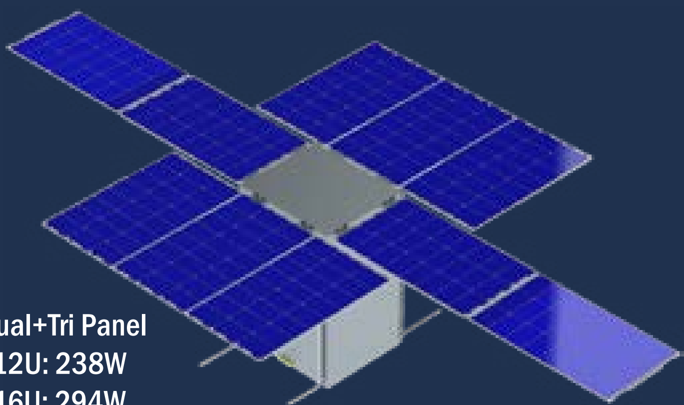
Dual Panel
6U/12U: 95W
8U/16U: 118W



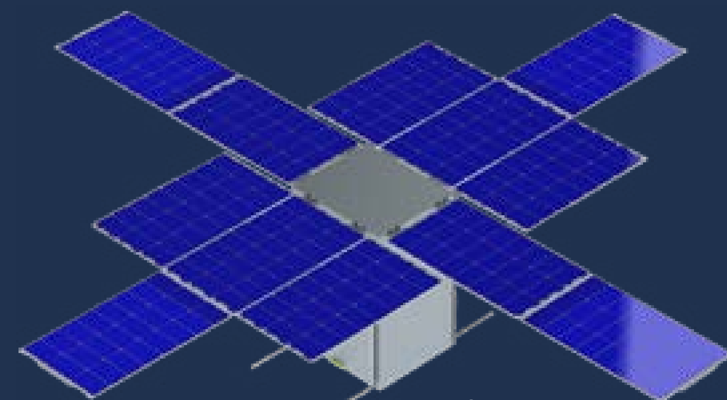
Tri-Panel
6U/12U: 143W
8U/16U: 176W



Quad Panel
6U/12U: 191W
8U/16U: 235W



Dual+Tri Panel
12U: 238W
16U: 294W



Dual+Quad Panel
12U: 286W
16U: 353W

infinite SCALABILITY

MMA's latest HaWK designs are optimized for cannister-deployed CubeSats. They maximize the power density on a solar array that fits on all four walls of a 12U/16U, or on opposite faces of a 6U/8U CubeSat. Coupled with proprietary solar cell sizes, this design enables you to *accomplish* approximately 50% MORE power for your mission than our classic HaWKs.

High Watts per Kilogram HaWK

Wing			Array Performance		W/kg (without SADA)		Stowed Height (mm)	MMA HaWK Part Number
Stowed Footprint (U)		Deployment Axis	Panels per Wing	Peak Power* (2 Wings)	Standard	High Performance		
1 x 3		α	3	44 W	104	133	7	**17A-44**
		α + ß(90deg)	3	43 W	96	129	6.5	**17AB43**
		α + SADA(ß)	3	44 W	99	127	6.5	**17AS44**
			4	59 W	91	155	8.5	**17AS59**
		α(long) z-fold	3	43 W	95	–	8	**17Z-43**
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**

* BOL, AM0. 28°C. Table above shows some existing HaWK configurations. Don't see what you need? No problem. Customization is our jam.

WE ARE...

Gear heads
Musicians
Car Nerds
Space Nuts
Dreamers
Animal Lovers
Artists
Creative
Foodies
Innovators
Playful
Family
Pilots
Inventors
Tinkerers
Travelers
Designers
Problem solvers
Disrupters
Teachers
Adventurers
Explorers

Technology Toolbox:

Coatings
Gimbals/SADAs
Thermal Knife
Motors and gear trains
Tape Drive Assemblies
Spring-energy, tape and motorized hinges
Slit-tube, Shearless, CTM and Truss Booms
Control Electronics and Emulators
Launch Restraints
Welded Assemblies
Gossamer Structures
Peak Power Trackers
Firmware/Software
Flat Diodes
Flex Circuits
Composites
Membranes

PEOPLE + TOOLS =

WE MAKE...

Antennas
Booms
Moving Mechanical Assemblies
Customers Happy
Space Stuff
Structures
Solar Arrays
Deployable Optics
Stuff that packages cleverly for launch and gets #HUGEinspace
Anything you can dream up
Terrestrial Stuff
Successful Missions
A Difference in the World
Other Deployable Solutions
infinite Possibilities a reality

LESS:	MORE:
	Capability
	Attention
	Testing
	Customer Service
	Quality
	Watts/m^3
	Aperture
	Gain
	Bandwidth
Drama	Innovation
Oversight	Rigor
Time	Simplicity
Money	Elegance
Mass	Heritage
Volume	Transparency
Parts count	Creativity
Complexity	Efficiency
Team size	Solutions

solutions that *accomplish* MORE

learn FAST

MMA Demonstrates Agility with Rapid Spacecraft Development on the RF Risk Reduction Deployment Demonstration "R3D2" Mission by Going from Concept to Spaceflight in 20 Months

As a small, agile team since our infancy, MMA has always found distinction in our ability to learn faster, work leaner, and iterate to deliver hardware more quickly than many of our contemporaries. So, when DARPA and Northrop Grumman approached us to adapt our P-DaHGR (pantograph deployable high-gain reflectarray) antenna concept for the R3D2 mission, it was time to put the pedal to our mettle.

We had already built a 5-meter P-DaHGR antenna, leveraging our learnings from other concepts and programs over the years. Our toolkit of thin-film membranes, pantographs, composite tapes and tape deployers, among other high-TRL subsystems, were the building blocks we scaled, adapted, tested and expeditiously put to task.

The R3D2 antenna, a 2.25-meter version of the same P-DaHGR architecture that stows in a 10U volume (2,250 m/m^3), went from CAD to low earth orbit in just 20 months, launching on a RocketLab Electron rocket in March of 2019, even while enduring the battery of tests required to reduce risk.

But speed was not the only critical metric on this mission. By compacting a large antenna into a small satellite with our unique membrane-based design, the spacecraft could provide significant RF sensor capability, without the need for large satellites that can only be launched on big rockets with hefty price tags.

We like to say that we think out of the box to put more into the box for our customers, and this collaboration on the R3D2 mission — with partners like DARPA and Northrop Grumman who share our passion for innovation and exploration — demonstrates this beautifully.

R3D2 stowed on the spacecraft (top), and being readied for deployment testing at MMA (bottom).

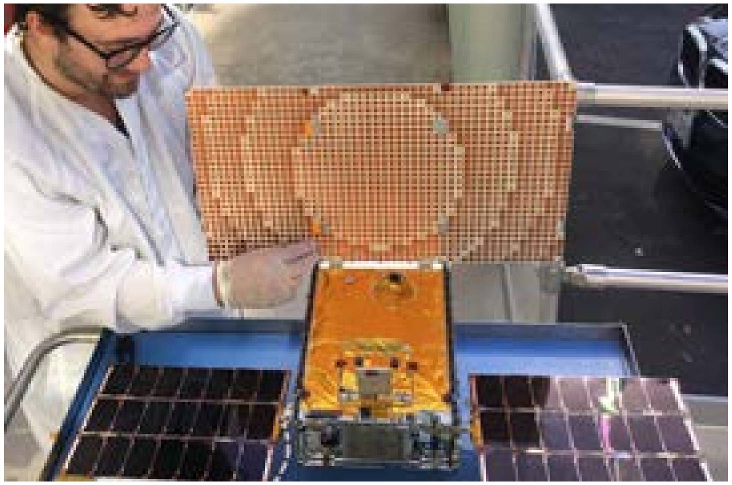
MMA HaWKs Power First Ever Interplanetary CubeSat Demonstration on JPL's Mars Cube One "MarCO" Mission

2019's SmallSat Mission of the Year, MarCOs A and B were the first CubeSats to ever set forth on a journey to deep space. Launching in May of 2018, MarCO's twin CubeSats, nicknamed Wall-E and Eva, arrived at the red planet six months later, in November of 2018. Their mission was to demonstrate that CubeSats could play an integral part in improving communications as the Mars InSight Lander entered Mars' atmosphere.

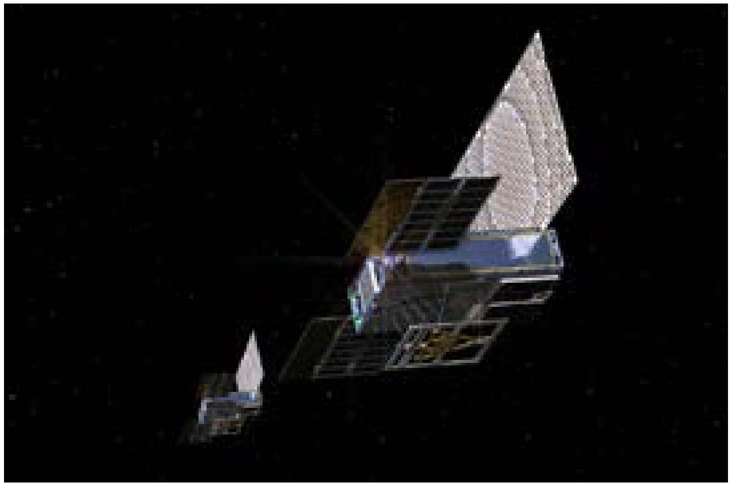
MMA's solar arrays provided critical space power to the two diminuitive satellites, with our first dual-axis deployment HaWKs, which exceeded power expectations on their trip to Mars. Thanks to the MarCO CubeSats, the InSight team learned of the lander's successful entry into Mars' atmosphere in near-real-time, instead of the previously standard 1+ hour delay.

The MarCO HaWK solar arrays were some of MMA's first solar arrays developed after achieving commercialization success with the AFRL HaWK under Small Business Innovation Research grants, or SBIRs. The requirements of the MarCO spacecraft and other constraints of the mission also brought about significant advancements in the technologies we originally developed. Specifically, critical improvements to our design of launch restraints were made, improving overall strength and reliability for the severe environments experienced during ascent and on-orbit. The hinge and spring innovations developed on MarCO have not only been flight proven in deep space, but are now standard components in many of the HaWK configurations we have delivered since.

Our work with JPL started with the MarCO mission, and has continued with ASTERIA, NeaScout and Lunar Flashlight. When two out of four missions win SmallSat Mission of the Year awards, you know you're doing something right.



A JPL engineer uses sunlight to test the HaWK solar arrays on one of the MarCO CubeSats. (Image courtesy of NASA/JPL)



MarCO Mission CubeSats on their way to Mars. (Rendering courtesy of NASA/JPL.)

do GOOD

MMA's dragNET De-orbit Cleans up Space in Low-Earth Orbit Without Tapping Precious Mission Resources or Impacting Satellite Performance

Tens of thousands of man-made pieces of debris are currently buzzing around us in a low-Earth orbit. Fragments spawned by the collision of those pieces, along with an ever-increasing rate of launch for new satellites and spacecraft, have created a growing field of space debris that poses a significant risk to critical communications (think Internet, cell phones and GPS), as well as banking systems, military surveillance operations and, someday soon, manned space flight.

With funding from an Air Force SBIR, MMA developed and successfully demonstrated a system to remove satellites from orbit — the dragNET De-orbit System. dragNET can be added to an existing spacecraft late in the integration stage and is easily scalable to various classes of vehicles.

The dragNET de-orbit system consists of compactly stowed, thin membranes that release using a single heater-powered actuator and stow in a box the size of a shoebox. Deployment is powered by releasing stored spring energy acting through articulating booms, and once tensioned, the 14 square-meter membranes create the necessary resistance to passively deorbit the spacecraft or launch vehicle. Although it only weighs about six pounds, the system can bring down a 181 kg, ESPA-class spacecraft from altitudes of about 850 km in less than 10 years. In fact, it successfully deorbited the upper stage of the ORS-3 Minotaur in 2013 in under 2 years.

One of MMA's earliest innovations — we might even call it "the one that started it all" — the dragNET De-orbit System not only put MMA Design on the map, but our learnings from this project inspired many of the technology innovations we leverage today from our technology toolkit to ensure that our solutions are not only revolutionary, but also time tested and flight proven.

The dragNET de-orbit system fully stowed and integrated on the STPSat-3 spacecraft.

*We appreciate the **collaboration, sense of urgency, open communication and transparency** we get from MMA. More than just a supplier, they are a **partner.***

dragNET De-Orbit System

our mission is to enable

FLIGHT HERITAGE: LEO, GEO, INTERPLANETARY AND BEYOND

dragNET De-Orbit System: Two of these launched on the 2013 Minotaur I ORS-3 Mission. One has already successfully de-orbited the upper stage of the launch vehicle.The other is on the STPSat-3 and is awaiting mission completion to activate.

FalconSAT-7: Launched in 2019, MMA provided a deployable membrane photon sieve to demonstrate large aperture optical telescope technologies. This mission aims to image the sun.

R3D2: Launched in 2019, DARPA's Radio Frequency Risk Reduction Deployment Demonstration mission proved that our P-DaHGR antenna could provide great capability in a small volume and in a very short time frame.

MMA's HaWK Solar Arrays: In 2017, MMA HaWks powered several missions, including successful operation on AFRL's **SHARC** mission. This HaWK accelerated the satellite's de-orbit at end-of-life to mitigate orbital debris.

Another HaWK is successfully powering the **ASTERIA** mission, 2018's SmallSat Mission of the Year. A technology demonstration, ASTERIA conducts astrophysical measurements using a CubeSat.

Launching in 2018, JPL's **MarCO** mission, powered by MMA HaWKs, sent twin CubeSats to Mars. MarCO successfully provided real-time data relay during descent and landing of the InSight Mars Lander.

YOUR MISSION

Several other HaWK Solar Arrays will be launching in 2021 on SLS, including **BioSentinel** which will measure the impact of space radiation on living organisms over long durations beyond LEO.

The **NeaScout** mission will return data from an asteroid representative of NEAs that may one day be human destinations.

LunarFlashlight explores ice deposits in the Moon's permanently shadowed craters.

LunaH-Map will search for hydrogen deposits on the Moon's south pole.

And, **EQUULEUS** will measure the distribution of plasma in Earth's plasmosphere to help us understand radiation there.

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2016 TIBBETTS AWARD WINNER!