

Located in Webster's backyard—NASA-Johnson Space Center (JSC) is just four miles east of Interstate 45 on NASA Parkway. From the early Gemini, Apollo, and Skylab Programs to today's International Space Station, Orion Program, and Crew Space Transportation Program, JSC leads NASA's human space exploration initiative.



As JSC employs over 13,500 civil servants, astronauts, and contractors, aerospace is important to the region and complements thriving industry sectors in Webster's super-regional market, like healthcare, biotechnology, higher education, specialty chemical, energy, environmental science, retail, entertainment, and tourism.



The International Space Station continues to be the centerpiece program for NASA and is operated from JSC.

In both the national and international arena, space is the high ground. NASA's JSC plays a critically vital role in the United States' leadership and security. The International Space Station (ISS), which joins 16 nations, continues to be a centerpiece program for NASA. This program, which is operated from JSC, will continue to be active at a minimum through 2023, as the ISS serves as a major base for scientific research and support for deep space exploration. One of Webster's leading aerospace companies, Stinger Ghaffarian Technologies, was awarded a nine-year \$1.1 billion NASA contract in

2014 to provide mission and flight crew operations for the International Space Station and the new Orion crew vehicle. Another Webster company, NanoRacks, transports scientific payloads to the ISS and maintains a permanent laboratory called "NanoLabs" aboard the International Space Station.

Inside the aerospace capital of the United States, Lockheed Martin continues its work on Orion, which is NASA's next-generation crew vehicle designed to replace the space shuttle and provide new transportation technology to support missions to low-Earth orbit, the Moon, asteroids, and deep space.



The Orion Capsule, which has been developed in Webster, will transport crews to the ISS and eventually to deep space.



CST-100 Starliner will transport crew and cargo to low-Earth orbit, such as the ISS.

NASA's \$4.2 billion contract with Boeing to build the CST-

100 Starliner spacecraft, launched aboard the Atlas V rocket, to transport astronauts and cargo to low-Earth orbit destinations, is underway. The Starliner is similar in shape to the Apollo spacecraft, but its electronics are half a century more advanced. The spacecraft is designed to carry up to seven astronauts.

As Boeing employs about 500 people locally to work on development of the commercial crew transportation system, the NASA contract has significant economic impact, as well as "space-race" impact. Boeing's development of a safe, reliable, and cost-effective solution for crew transportation to and from the International Space Station and future space habitats is a boon to Bay Area Houston and a boost to America's space prowess.

Johnson Space Center’s activities account for more than 13,500 jobs, \$2.5 billion in personal income, a highly educated workforce, and a solid community partnership that is strongly supported by bipartisan political leadership. Johnson Space Center is symbolic of America’s strength, security, and innovation.



Johnson Space Center is Mission Control

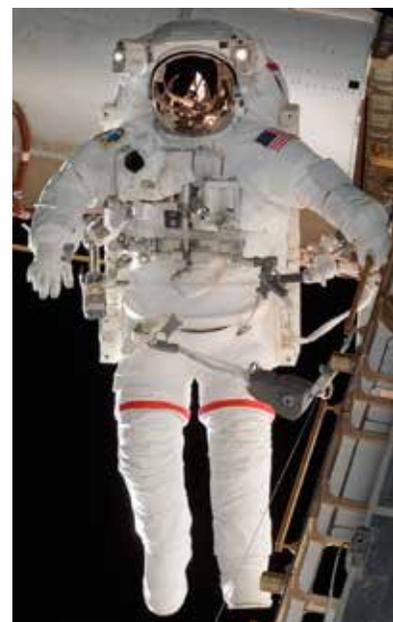
Johnson Space Center is renowned for being the home of the International Space Station Flight Control Room (Mission Control), where flight controllers command, monitor, and plan operations. The management of activities for all manned spaceflight missions, including the U.S. portions of the ISS, is headquartered at JSC.

Largest Johnson Space Center Contractors in the Bay Area

- Ad Astra Rocket Company..... 141 W. Bay Area Blvd
- Barrios Technology, Inc: 2525 Bay Area Blvd.
- Boeing NASA Systems: 3100 Space Center Blvd.
- GB Tech Inc: 2200 Space Park Dr.
- Lockheed Martin: 505 Forge River Rd.
- MEI Technologies, Inc: 2525 Bay Area Blvd.
- Nanoracks..... 17155 Feathercraft
- Oceaneering Space Systems: 16665 Space Center Blvd.
- SGT, Inc: 17155 Feathercraft
- Universities Space Research Association: 3600 Bay Area Blvd.
- Wyle Laboratories Inc: 1290 Hercules

SGT’s role on ISS

Webster’s identity is firmly entrenched in aerospace, as Johnson Space Center is in the municipality’s backyard. Since 1961 to today, the space agency’s role of designing and developing spacecraft and operating those vehicles in space continues to be highly relevant, as unfathomable, uncharted realms beckon. As Johnson Space Center is home to Mission Control and the Astronaut Corps and oversees systems for human spaceflight and operations of the International Space Station, a major NASA contractor, Stinger Ghaffarian Technologies (SGT), with two Webster facilities, supports these activities in a very meaningful and extensive way. In July 2013, SGT was awarded an eight-year \$63 million NASA contract to provide logistics and operational support for the Extravehicular Activity (EVA) Space Operations Program. A year later, SGT was awarded a nine-year \$1.1 billion NASA contract to provide mission and flight crew operations for the International Space Station and the new Orion crew vehicle. Not only does SGT design, test, and maintain spacesuits for astronauts in route to and aboard the ISS but also the science



Stinger Ghaffarian Technologies, with a state of the art Webster facility, oversees every aspect of spacesuits – engineering, maintenance, testing, and training.

and engineering services company trains astronauts for myriad duties – flight, maintenance and operations of ISS systems, and exploration. With over two decades of experience supporting operational aspects of NASA’s human spaceflight programs, SGT oversees just about every ISS activity. SGT is the second largest engineering support contractor for NASA and has a local workforce of 600 with 80 people dedicated to spacesuits and its many hardware components – like portable life support system, carbon dioxide elimination, temperature regulation, communication system, waste collection, radiation shielding, maneuverability components, and so much more.

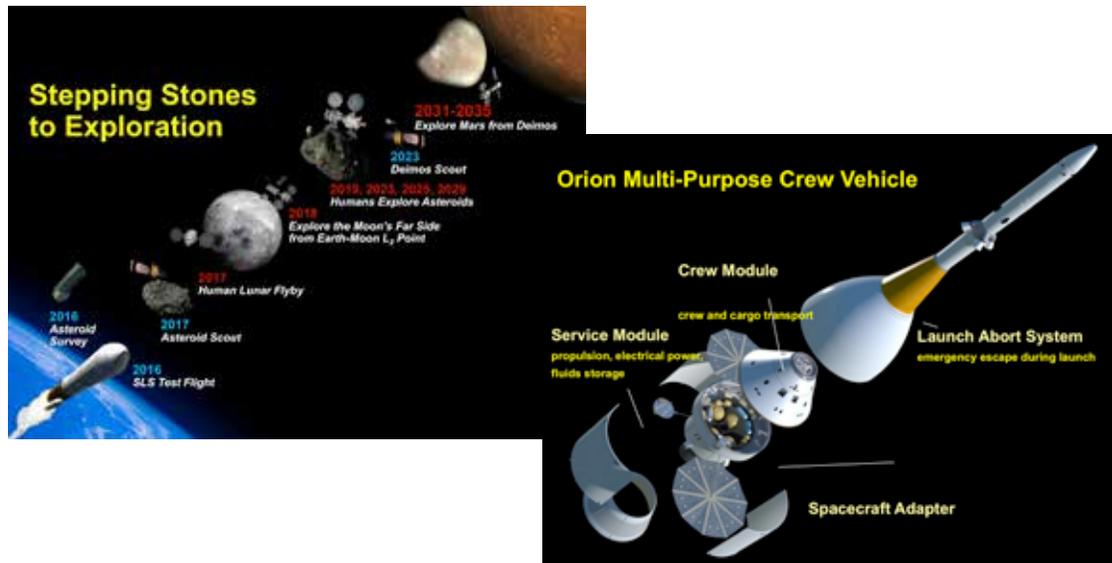
Orion – America’s Leadership Continues

What sets NASA apart from other countries’ space programs is the human exploration element. While 584 humans have flown into space, only 24 of those pioneers have ventured beyond low earth orbit, and they have all been Americans. NASA’s focus continues to be on human spaceflight, and the headquarters for human space exploration is Johnson Space Center. In support of the human spaceflight mission, Lockheed Martin has developed Orion, the multi-purpose crew vehicle that will extend the nation’s human spaceflight leadership in space exploration beyond low earth orbit. Orion has been designed and is being tested to transport a crew of up to six to the moon, asteroids, moons of Mars, Mars, and beyond.

Orion is a magical machine, according to Laurence Price, Lockheed Martin’s Space Systems’ Deputy Program Manager for Orion, in that it supports life for extended periods of time with its self-sustaining atmosphere, propulsion, and backup systems. Unlike previous technology, this vehicle is designed for human habitation for three weeks and “stand-by” or no habitation for six months. Under this scenario, Orion transports up to six astronauts to an asteroid (perceived as a building block of the solar system) where research is conducted for several months. Orion orbits during this interval until it is time for the return voyage to Earth.

A highly successful test flight for Orion transpired in December 2014 when Orion orbited Earth twice with the second orbit taking the capsule about 3,600 miles away from Earth’s surface—14 times farther than the orbit of the International Space Station. This test flight, known as EFT-1, provided over 500 gigabytes of data reflecting vehicle performance in the areas of separation events, guidance and navigation, crew environmental control, and radiation protection.

Orion’s technology is revolutionizing space transport systems – navigation and docking, risk mitigation, propulsion, energy and regenerative power, life support, and communications – as Orion is the most advanced space vehicle in existence. While Lockheed Martin’s Exploration Development Laboratory is headquartered in Webster, there are 3,500 people in 30 states working on all aspects of this monumental program.



Rocket Science inside the Aerospace Capital

Rocket science that is revolutionizing in-space propulsion with profound implications for space exploration, orbital debris disposal, and new energy applications is transpiring in Webster. Webster is home to one of the world’s most innovative aerospace firms—Ad Astra Rocket Company. Dr. Franklin Chang Diaz, inventor of the Variable Specific Impulse Magnetoplasma Rocket (VASIMR®), founded Ad Astra Rocket Company in 2005, after serving for more than 25 years as a NASA astronaut. Chang Diaz, as a veteran of seven Space Shuttle missions, holds the record for the most spaceflights and credits his years as an astronaut to inspiring his concepts for transforming space transportation and exploration.



Dr. Franklin Chang Diaz founded Ad Astra Rocket Company to develop VASIMR®.

Chang Diaz who graduated with a PhD in plasma physics from MIT in 1977, along with a brilliant team of physicists, has recently completed arduous testing of Ad Astra’s VX-200 (VASIMR® experimental engine) to demonstrate that this prototype is the most efficient and powerful electric thruster in operation today.

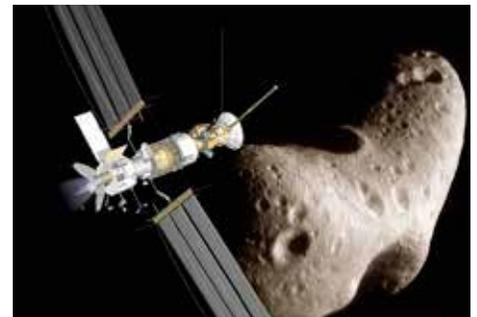
The company, Ad Astra, which is Latin for “to the stars” was founded to develop, test, and commercialize the technology of the VASIMR® engine, a plasma propulsion system that is much more fuel efficient and faster than traditional chemical rockets. Lengthy journeys to the planets and stars require a new technology that relies on the power of plasma accelerated by electric and magnetic fields. Whereas today’s chemical rockets utilize extensive amounts of propellant that constitute most of the ship’s mass to produce short bursts of thrust, the VASIMR®, with its plasma exhaust, is much hotter, consumes propellant

more frugally, and provides constant power throttling or continuous thrust to enable journeys to more distant destinations, quicker flights, and larger payload capacities.

The VASIMR® propulsion system powered by just 200 megawatts of electrical power could result in a ship’s reaching Mars in 39 days, rather than eight months with a chemical rocket, and significantly reduce the crew’s exposure to weightlessness and deadly space radiation. Many applications are in store for the VASIMR®, including asteroid missions, orbital debris disposal, the Catapult, and Project Aurora.

VASIMR® Asteroid Mission

Since asteroids are of significant import to scientists, entrepreneurs, and humanity, the combination of VASIMR®’s high exhaust velocity and fuel efficiency with advanced, lightweight solar arrays, like the Boeing FAST array, will enable ambitious robotic missions to explore near-Earth objects within a few years. As there are several hundred thousand asteroids within the solar system and nearly that number newly discovered every year, exploration of asteroids can reveal the geological formation of the planets, dwarf planets, and small bodies within the Sun’s gravitational control, provide an abundant source of precious metals, and assist in formulating methods to divert those threatening Earth.



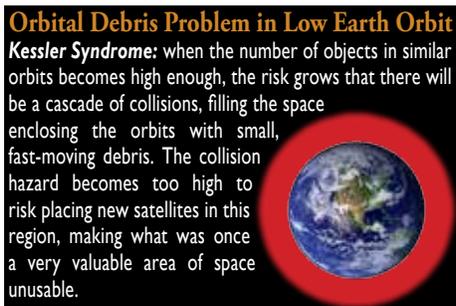
The VASIMR® Asteroid Mission will reveal information about the origins of the solar system, assist in diversion of objects that threaten Earth, and provide a source of precious minerals.

VASIMR® Orbital Debris Disposal

With tens of thousands of space debris objects, ranging in mass from nuts and bolts to large dead reconnaissance satellites weighing as much as ten tons, space debris disposal and reduction is critical. Also, since low polar orbits are invaluable space real estate, in that satellites

within this orbit can view the entire Earth daily, the United States and other countries have been periodically launching massive satellites (those weighing ten tons) into polar orbits for decades. However, more than 80% of these satellites no longer function due to attitude-control propellant depletion or instrument failure. With billions of dollars invested annually into building and launching these satellites, highly valuable assets are flying in a region of space where the chance of destructive collision multiplies.

A VASIMR®-propelled vehicle, with a “fuel efficiency” more than ten times that of a chemical rocket and advanced maneuverability to shift to a polar orbit at varying longitudes, can be utilized to move the largest dead satellites to a lower orbit where they can safely burn up in the atmosphere.



In 1978, NASA scientist Donald J. Kessler proposed a scenario whereby collisions between objects in low Earth orbit cause a cascade effect – each explosion spreading debris that increases the likelihood of additional collisions.

of the Sun and the principle of the medieval catapult. Just as catapults could generate tremendous force and hurl large objects over great distances, the VASIMR®, along with its payload, is flown on a path that sweeps closer to the Sun than the Earth, amassing large quantities of power generated from solar arrays, causing the vehicle to produce huge thrust capacity and speed, enabling the payload to be released, and allowing the cargo to coast to an outer solar system destination, like Jupiter. Since the VASIMR® engine and its solar array would not be effective in the outer solar system due to the dim sunlight, after the payload is released, the VASIMR® returns to an orbit around Earth to be utilized for another mission.

The VASIMR® Catapult has the potential to make journeys to destinations that have previously been considered “out of this world” a reality. With this technology, unmanned probes to Mars, Jupiter, and Saturn can be delivered in less time or with more payload mass.

Project Aurora

The Aurora Mission, Ad Astra’s first commercial electric power and propulsion test-bed, is designed to operate as part of the International Space Station (ISS). The VASIMR® engine will be delivered to the ISS by a commercial launcher and robotic orbit transfer vehicle and tested in the space environment in support of future commercial human and robotic transportation missions in near Earth and interplanetary space. As part of a Space Act Agreement between Ad Astra and NASA, the Aurora Mission spans several years to provide accurate measurements of the VASIMR®, as well as the space environment around the ISS.

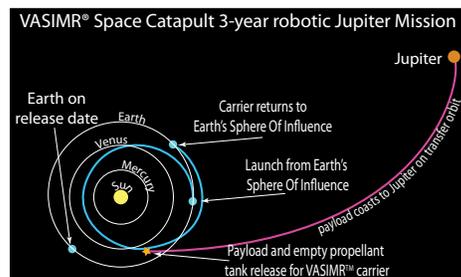
“Aurora,” which translates as “sunrise” in Spanish, is fitting for the dawn of new technology in space propulsion with plasma resembling a miniature sun. The plasma rocket, with its high temperature exhaust and fuel efficiency, is designed with two side by side magnetic nozzles—both positive and negative—to ensure magnetic stability on the ISS.

Garbage Collectors of Space

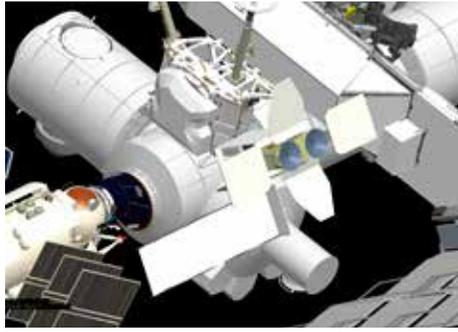
Ad Astra seeks to collect and service space debris, as there are approximately 500,000 orbiting objects in space that need to be serviced or removed. Ad Astra’s VASIMR® Orbital Disposal Mission would assist in countering the Kessler Syndrome in which collision of dead satellites results in the proliferation of orbital debris and exponentially increases the probability of destructive impacts.

VASIMR® Catapult

Ad Astra has devised a concept for sending VASIMR® payloads into the outer solar system by using the power of the Sun and the principle of the medieval catapult. Just as catapults could generate tremendous



Using the gravitational pull and solar energy from the Sun, VASIMR® could deliver payloads to Jupiter.



Project Aurora features the VASIMR[®] aboard the International Space Station.

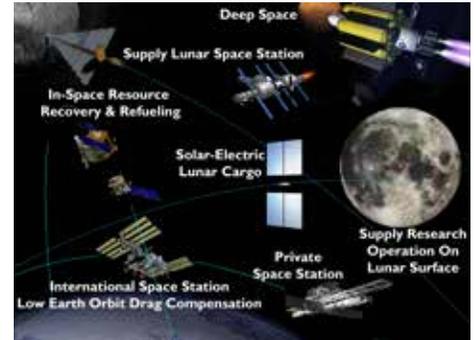
Other key components of Project Aurora include advanced high temperature radiators that remove excess heat from the rocket, advanced radio frequency generators that produce the electromagnetic waves that create and accelerate the plasma, and the high-temperature superconducting magnet, developed jointly by Ad Astra and Superpower, Inc, which represents the first of its kind in a space application.

Future Missions

For missions to Mars and beyond, Dr. Franklin Chang Diaz' design for next generation VASIMR[®] rockets relies on the development of lightweight, high-power nuclear energy sources that can generate hundreds of megawatts of electricity in space. At the front of the advanced VASIMR[®] vehicle, pictured above, is a lander that will take the crew down to Mars' surface. Gold-colored insulated propellant tanks are clustered around a cylindrical habitat for the crew for protection against high-energy radiation within the space environment. Nuclear electric powerplants generate electricity to run the VASIMR[®] engines that propel the vehicle while cruciform booms carry heat from the powerplants to large outward-facing radiators, which eject the waste heat to space. Behind the powerplants is the blue glow of the plasma exhaust from the VASIMR[®] engines.

Potential VASIMR[®] Applications

Whereas the link between aerospace research and development and many other disciplines—medicine, defense, environmental science, information technology, biotechnology, natural science, and engineering—has always been connected, today the implications are even more profound and visible. Ad Astra's development of a highly efficient helicon plasma source could have significant ramifications for generating energy on Earth, just as the VASIMR's reliance on lightweight, efficient superconducting electromagnets for propulsion translates into similar magnetic field geometries for portable oxygen units, MRI equipment, and other medical apparatus, as well as energy, military/defense, and transportation applications.



Applications for VASIMR[™] include deep space exploration & cargo transport

Ad Astra stands ready to continue its work on the VASIMR[®], which requires only a fraction of the propellant mass of chemical rockets for unmanned cargo flights to the Moon, Mars, and outer solar system to enable more sizable and useful payloads to be delivered without building new, larger launch vehicles. Lunar cargo, Mars sample return missions, and robotic probes to Jupiter are viable applications for VASIMR[®]. Further, the company's testing of VX-200 (VASIMR[®] experimental engine) in the large vacuum chamber in Webster the upgrade to a superconducting magnet operation, the improvements to support systems, and the completion of 2,000 firing cycles of the powerful plasma device translate into preparing the VF-200 engine for spaceflight, which is transpiring now. The Aurora Mission enhances the United States' portion of the ISS as a national laboratory.

Flight demonstrations are projected to start in 2020, and Ad Astra hopes to have commercial engine operations in space in 2023 or 2024.

Boeing's Crew Transport

Webster and the region are firmly entrenched in spacecraft design, travel, and operations.

NASA's \$4.2 billion contract with Boeing to build the CST-100 Starliner spacecraft, launched aboard the Atlas V rocket, to transport astronauts and cargo to low-Earth orbit destinations, such as the International Space Station, is under development. As Boeing employs about 500 people locally to work on design and development of the commercial crew transportation system, the NASA contract has significant economic impact, as well as "space-race" impact. Boeing's development of a safe, reliable, and cost-effective solution for



Boeing's commercial crew transportation vehicle represents an end to American dependence on foreign governments to travel to the ISS. Every seat that an American astronaut occupies on the Russian Soyuz costs \$76 million.

crew transportation to and from the International Space Station and future space habitats is a boon to Bay Area Houston and a boost to America's space prowess.

Retired US Navy Captain and former NASA Astronaut Chris Ferguson, named Director of Crew and Mission Operations for the Boeing Commercial Crew Program in 2011, led Boeing's team in developing the winning spacecraft design that has met extensive milestones. Ferguson's unparalleled qualifications as pilot of STS-115 (Atlantis), commander of STS-126 (Endeavor), and commander of final shuttle mission STS-135 (Atlantis), as well as logging 40 days in space and 5,700 hours in high performance aircraft, presiding as former deputy chief of the Astronaut Office and spacecraft commander (CAPCOM) for four missions, prepared him to be the hands-down expert to provide comprehensive oversight in the design of the CST-100. While the CST-100 (acronym for crew space transportation and 100km – the Karman line that defines the boundary of space) might resemble other spacecraft in shape or external design, Boeing's crew capsule possesses revolutionary attributes. The CST-100, designed to support larger crews of up to seven people for six months on-orbit, is reusable for ten missions, features an innovative weldless structure, and is compatible with multiple launch vehicles, such as Atlas V.

Boeing's celebrated CST-100 Starliner, which is slated to complete its first test mission in fall 2019, accomplishes many feats. Of great import to American self-reliance, the spacecraft will eliminate dependence on foreign launch services. As safe, reliable, and sustainable commercial crew transportation is essential to the operations and longevity of the International Space Station and provides a pathway to future deep space missions, Boeing's crew transportation system represents a major achievement not only for the company that has been a leading provider of human spaceflight systems and services for more than a half century but also the region and nation.

Certainly, this company seeks to propel America's space exploration program to new heights – transporting astronauts to Mars and beyond, just as it has celebrated past victories – lunar footsteps, space shuttle launches, and assembly of an orbital research facility.

Nanoracks

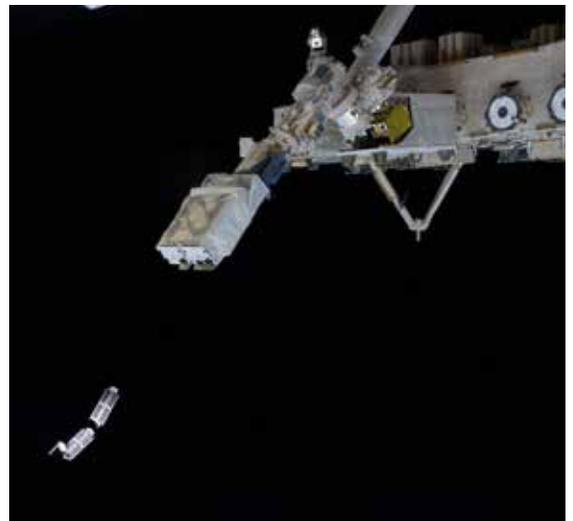
Webster's "Concierge to the Stars," the "FedEx to Outer Space," is the "Commercial Doorway to Space" with its latest platform—the NanoRacks Airlock.

One of the City's most innovative aerospace companies, NanoRacks, with its headquarters at 17155 Feathercraft is revolutionizing commercial space logistics. In fact, NanoRacks is the only private company that works with a full range of countries, governments, agencies, institutions, and businesses—around the globe—to transport satellites, scientific experiments, communication and observation sensors and devices to the International Space Station and low Earth orbit.

Since the company's inception, NanoRacks has been the pioneer in deploying over 300 payloads to space using NanoRacks facilities and systems on the ISS. The impetus behind the company's remarkable innovations and rapid growth in creating the pathway to space is an increasing global demand for enhanced communications and observation—for Earth, along with research conducted in zero gravity.

Building a Bigger Doorway to Space

What NanoRacks proposes is not only an airlock larger than the current airlock but also one that the company designs, builds, and owns. NASA would install the \$12M to \$15M NanoRacks Airlock on the ISS' Node 3. While the benefits to NanoRacks, NASA, and a growing worldwide clientele are immense, this airlock innovation and investment truly prolongs the life and utilization of the ISS, as the commercialization of space is vital to funding research and operations, propelling new projects and exploration globally, and transforming life on Planet Earth. The NanoRacks Airlock System provides the opportunity for increasing the size, number, and frequency for payloads to the ISS and deployment from the ISS.

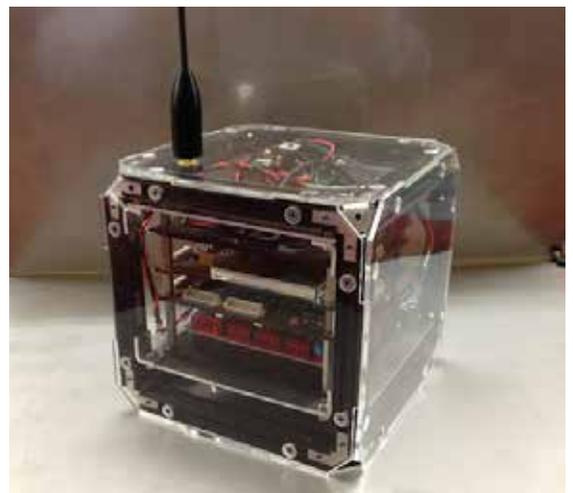


Two NanoRacks modules, each containing up to three CubeSats, are deployed from the Japanese Robotic Arm aboard the International Space Station.

Space Logistics – the First of its Kind

From start to finish, this commercial launch services company handles complex paperwork, takes the payload through all three phases of NASA's rigorous safety protocols, manifests the payload for flight on a commercial launch vehicle, runs the on-orbit operations of the payload or experiment, including astronaut crew time, and returns payload—if needed.

Satellites for observation and communication are in demand on a global scale. NanoRacks has launched over 96 CubeSats to date. In March 2016, NanoRacks processed 29 CubeSats (small satellites, roughly the size of a shoebox) for launch aboard the Orbital-ATK-6. Below, the graphics illustrate some of the steps required to deploy these CubeSats from the International Space Station (ISS).



This NanoRacks' single-unit CubeSat will be deployed from the International Space Station.