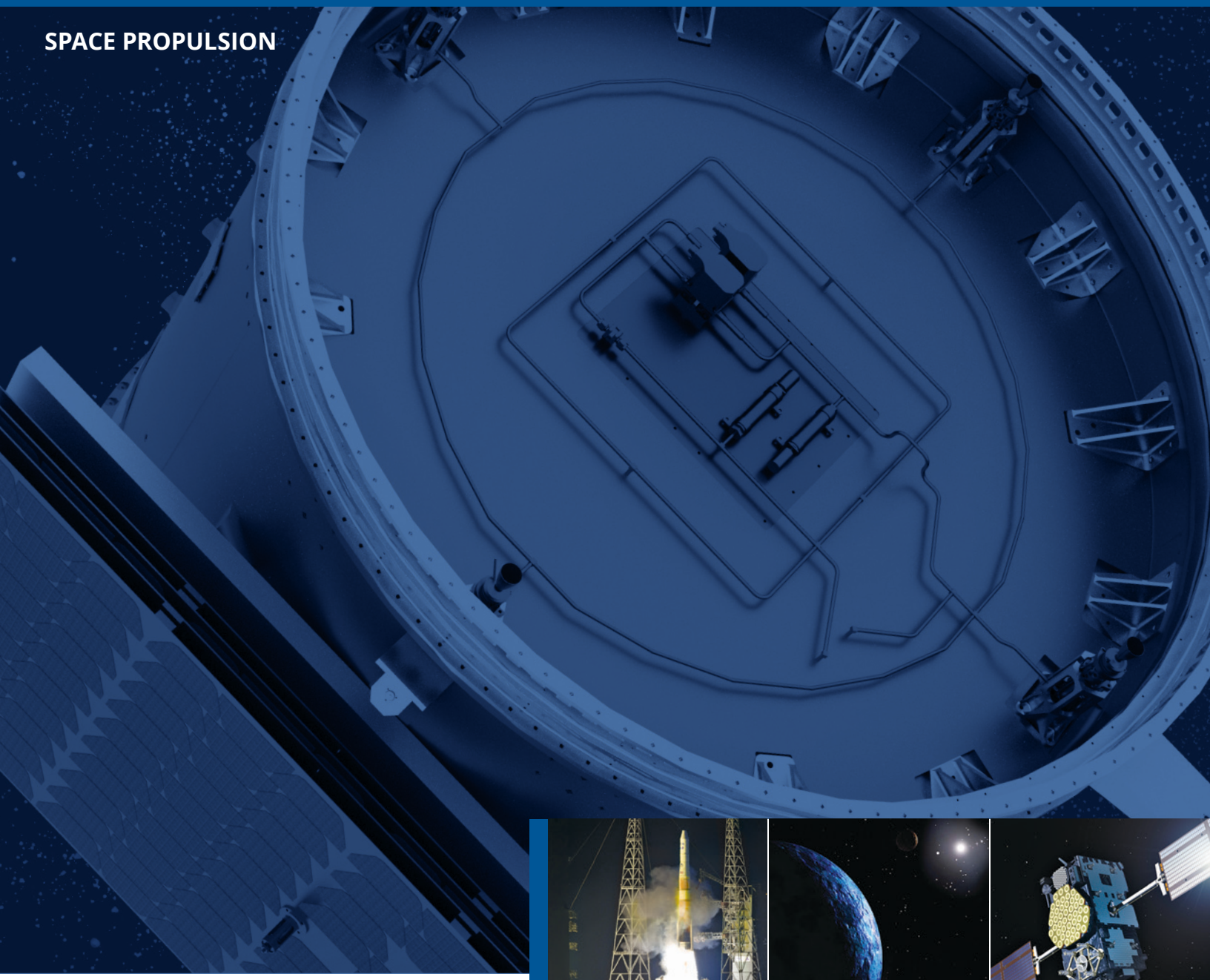


SPACE PROPULSION SOLUTIONS

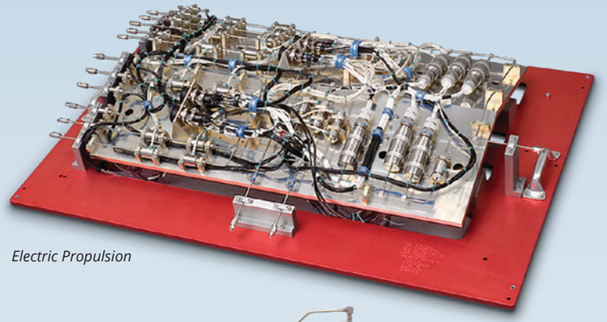
MOOG

WHAT WE DO IN PROPULSION

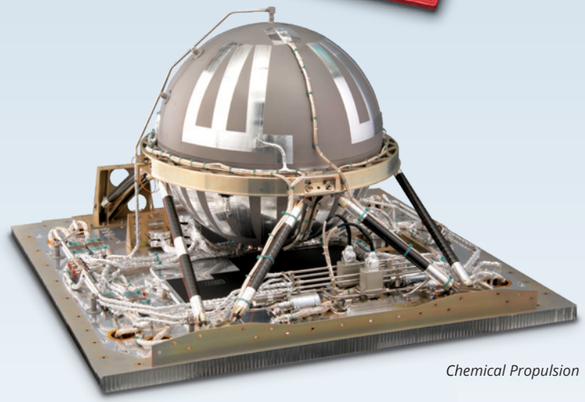
Moog is a leader in propulsion controls for spacecraft, launch vehicles, and tactical missiles, delivering flight-proven systems and components for every stage of a mission. Our propulsion expertise dates back to the 1940s, and through on-going research and development, our team is developing higher performance engines and innovative propulsion systems. Moog is leveraging its expertise in thermal management and high-performance thrusters to develop and supply components such as thrusters, valves, and tanks for use with less toxic or "green" propellants. Moog continues to make significant investments in our propulsion facilities, including in-house engine hot-fire test cells, which allow rapid evaluation of new thruster designs. We offer full propulsion system support, including design, analysis, assembly, and testing of mechanical, electrical, and thermal hardware.

Our expertise includes, but is not limited to, complete propulsion systems, subsystems, thrusters, tanks, and various fluid control components in support of:

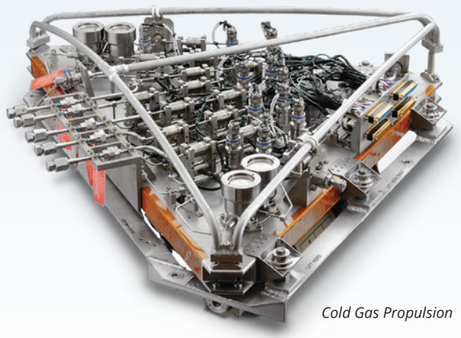
- Monopropellant and bipropellant chemical propulsion
- Cold gas propulsion
- Green propulsion
- Electric propulsion



Electric Propulsion



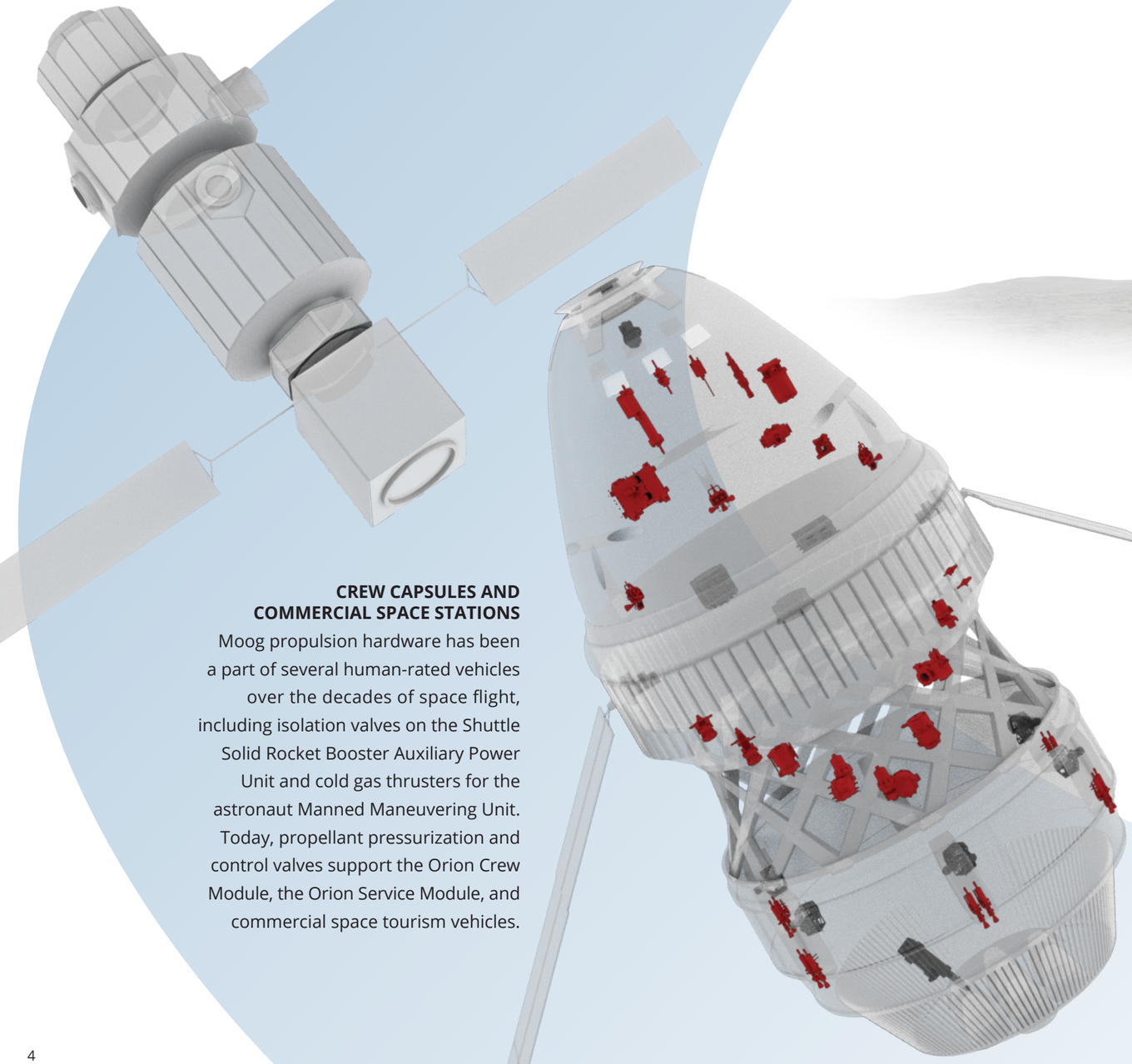
Chemical Propulsion



Cold Gas Propulsion

CREWED AND PLANETARY EXPLORATION

Moog has a long history of supporting space exploration with our propulsion hardware. We have thrusters and fluid-control components on NASA's Gateway, supporting the next generation of lunar and deep space exploration. Our technology has also been instrumental in the success of several missions to Mars, including Curiosity and Perseverance. In addition, Moog continues to support NASA aboard OSIRIS-REx on its missions to the asteroids Bennu and Apophis. The Moog team designed, built, and tested several components essential to these missions.



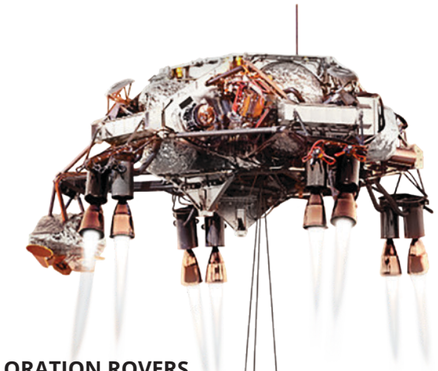
CREW CAPSULES AND COMMERCIAL SPACE STATIONS

Moog propulsion hardware has been a part of several human-rated vehicles over the decades of space flight, including isolation valves on the Shuttle Solid Rocket Booster Auxiliary Power Unit and cold gas thrusters for the astronaut Manned Maneuvering Unit. Today, propellant pressurization and control valves support the Orion Crew Module, the Orion Service Module, and commercial space tourism vehicles.

OSIRIS-REx – NASA

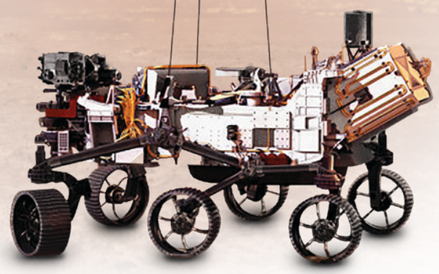
ASTEROID SAMPLE COLLECTION

Our latch valves and fill-and-drain valves continue to support the hydrazine propulsion system on OSIRIS-REx, NASA's first mission that successfully collected samples from an asteroid. That flight to Bennu and back took more than seven years and 4.4 billion miles. Moog continues to enable the OSIRIS-REx spacecraft on its extended mission to the asteroid Apophis. It is expected to arrive in 2029.



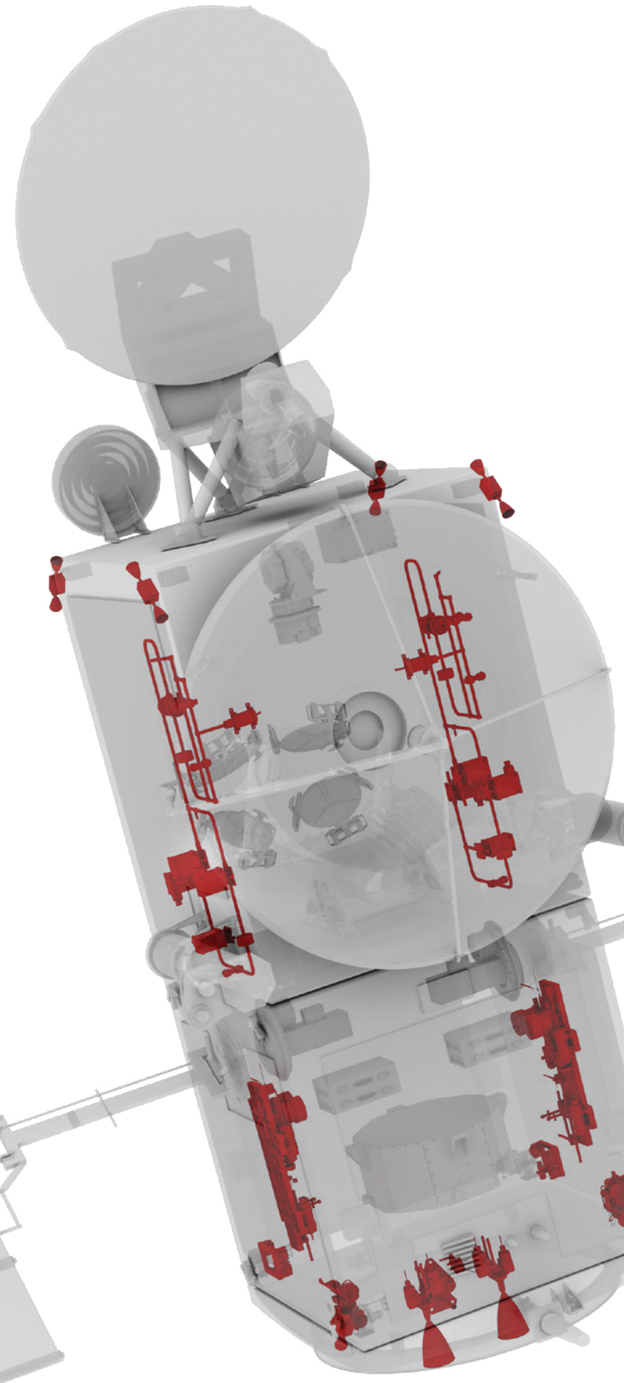
MARS EXPLORATION ROVERS

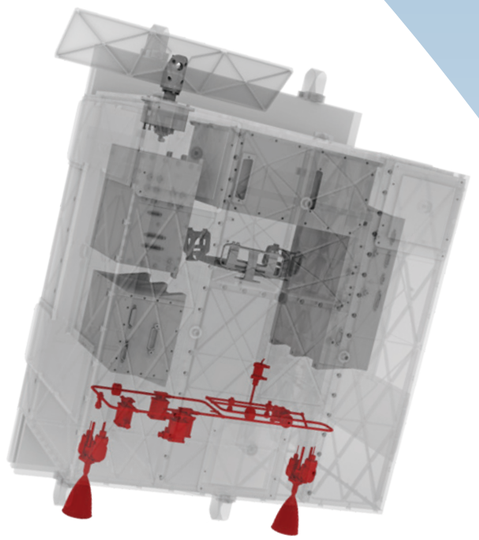
Moog propulsion technology has been critical to each Mars surface exploration. Most recently, we supported all stages of the Perseverence Mission, including thrusters and throttle valve assemblies during the cruise, entry, descent, and landing phases. Moog thrusters and torque motor latch valves have already been selected for the Mars Sample Return mission, which will bring the elements collected by the Perseverance rover back to earth.



Perseverance Rover – NASA

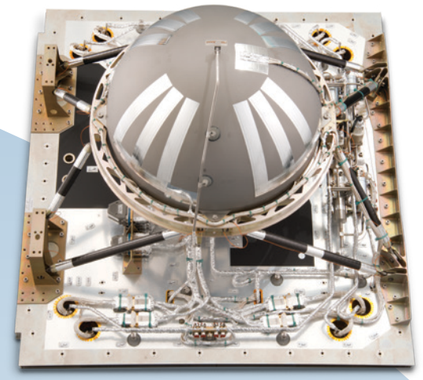
SPACECRAFT PROPULSION





INTEGRATED PROPULSION SYSTEMS AND SUBSYSTEMS

We supply complete tank-to-thruster propulsion systems and subassemblies for chemical, electric, and cold gas applications. These systems also typically include Moog-manufactured components and structures.

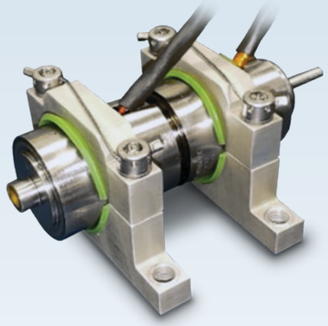


MONOPROPELLANT AND BIPROPELLANT THRUSTERS

Our chemical thrusters support both hydrazine and green propellants for spacecraft and flight vehicle attitude and roll control for commercial, exploration, and defense applications. Our thrusters range from 1N to 500N. Moog is also developing new thrusters for evolving mission requirements.

COLD GAS THRUSTERS

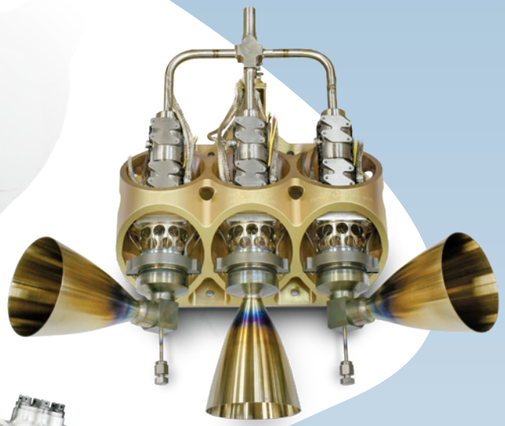
Our cold gas thruster designs are compatible with inert gases to support thrust, attitude control, and momentum transfer applications. Our thrusters range from <1N to 645N. They have been used on satellites, deep space missions, and untethered space walks. We have also demonstrated this technology in support of xenon electric propulsion.



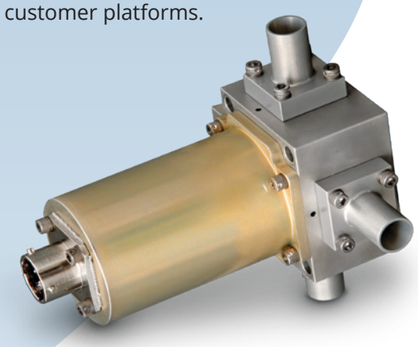
VALVES AND REGULATORS

Our propulsion control valves and regulators provide solutions for several spacecraft applications, including attitude control, orbit insertion, descent, and regulating propellant feed system pressure.

LAUNCH VEHICLE PROPULSION



PROPULSION SUBSYSTEMS
Subsystems on launch vehicles, missiles, and missile defense systems provide control and isolation for propellants. Components for each subsystem are procured, tested, cleaned, and then welded into the module to create the completed system. Moog also offers integration of subsystems onto customer platforms.



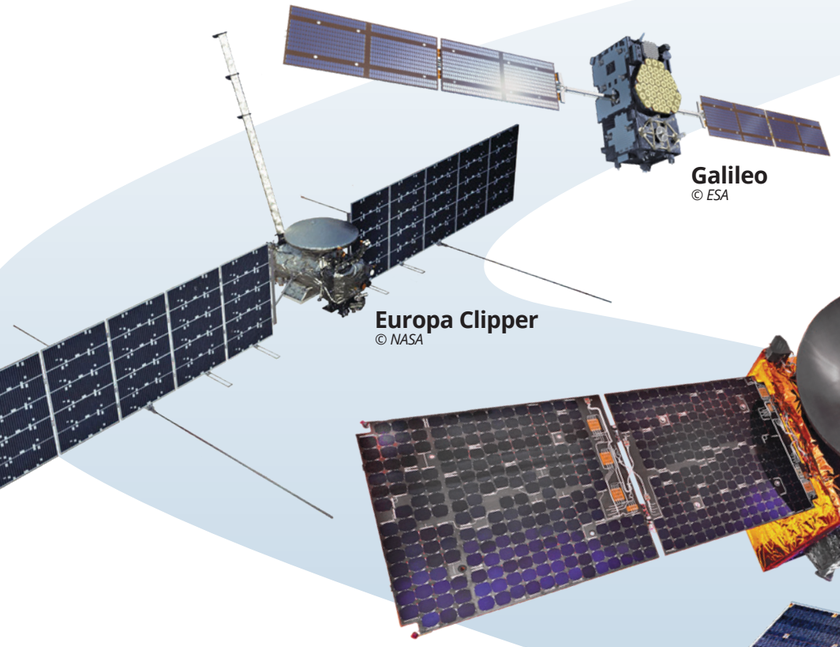
ATTITUDE AND ROLL CONTROL THRUSTERS
Moog provides attitude and roll control thrusters for several propellant types: regulated or blowdown cold gas, monopropellant and bipropellant, and hot gas.

CRYOGENIC ENGINE INLET VALVES
Our cryogenic fuel and oxidizer engine inlet valves and valve actuators deliver high flow at precise response times to ensure proper start-up pressurization for booster and upper stage rocket engines. They are engineered for liquid hydrogen and liquid oxygen environments.

FLUID TRANSFER COUPLINGS
The Moog fluid transfer coupling design incorporates passive and active coupling halves that have a simple engagement mechanism to provide low leakage transfer of gases or liquids used for space applications. This design accommodates some misalignment with or without a locking feature and is capable of operating at high pressures.

VENT AND PRESSURE CONTROL VALVES
Venting and pressure control valves are used to maintain tank pressure, propellant density, and settling by venting high pressure gas from the system. They are engineered for liquid hydrogen and liquid oxygen environments.

SPACECRAFT PROPULSION EXPERIENCE



Galileo
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Europa Clipper
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Hope Probe
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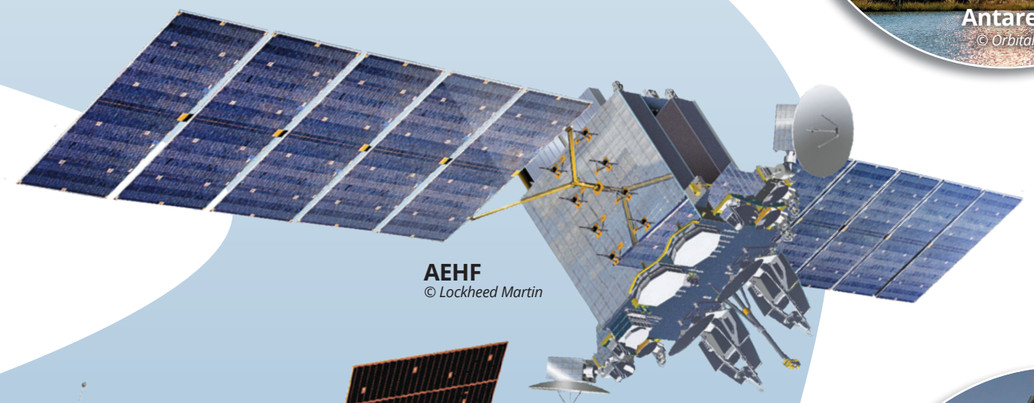

AEHF
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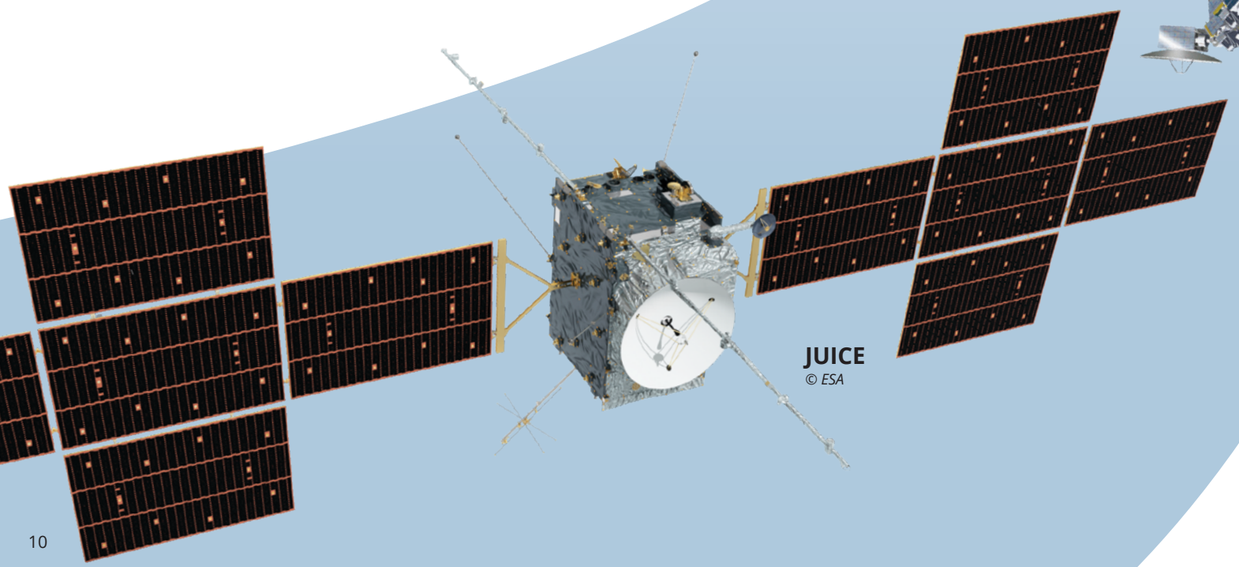

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LAUNCH VEHICLE PROPULSION EXPERIENCE

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