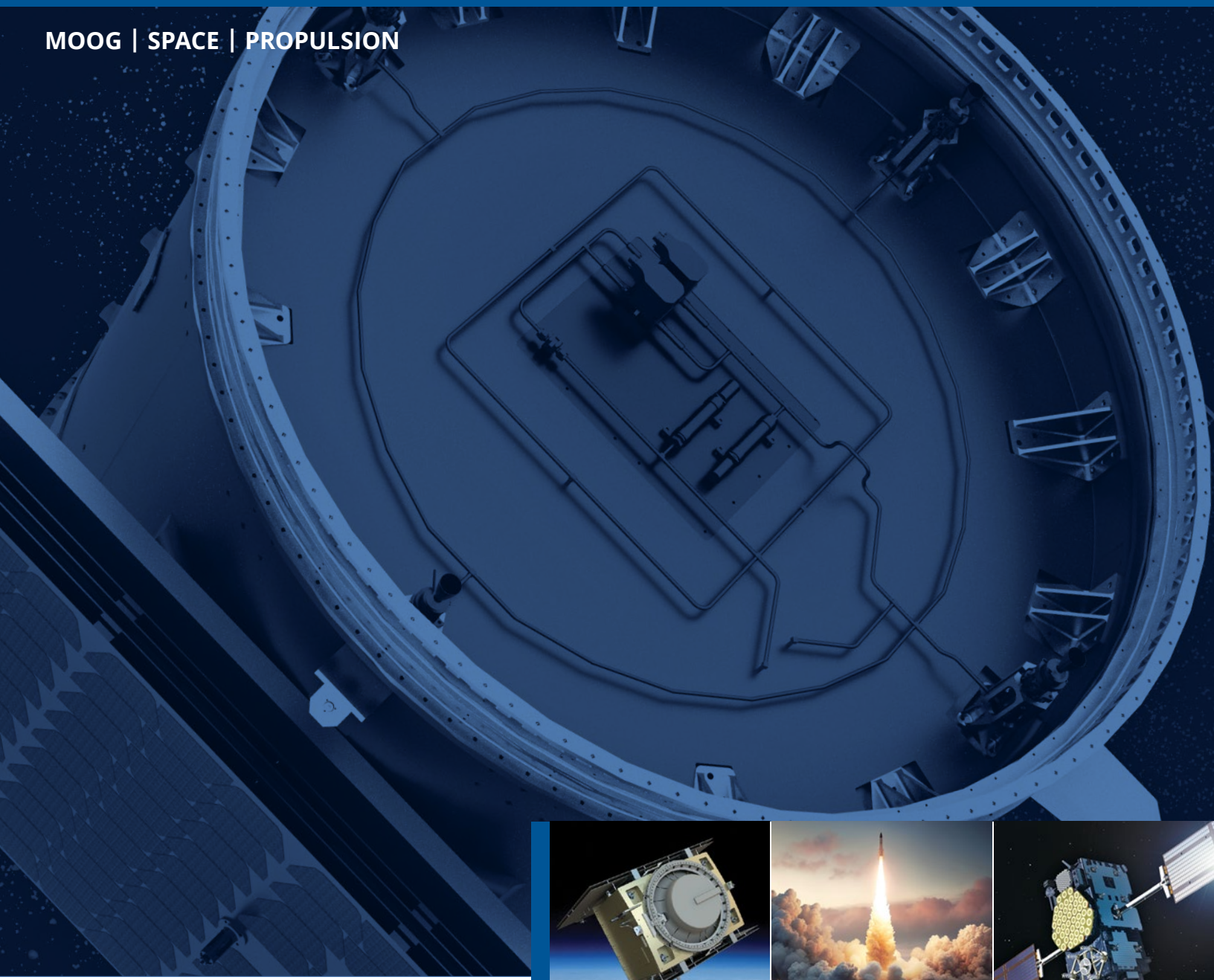
MOOG | SPACE | PROPULSION



SPACE PROPULSION SOLUTIONS

MOOG

WHAT WE DO IN PROPULSION

Who we are:

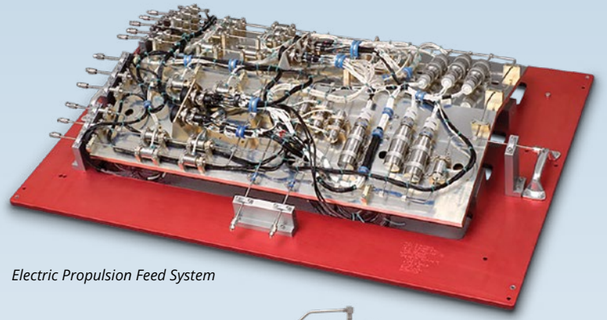
- Spacecraft, Launch Vehicle, and missile applications
- Propellant control components
- Thrusters across a variety thrust classes
- Propulsion systems
- Heritage dating back to the 1940s

Our capabilities:

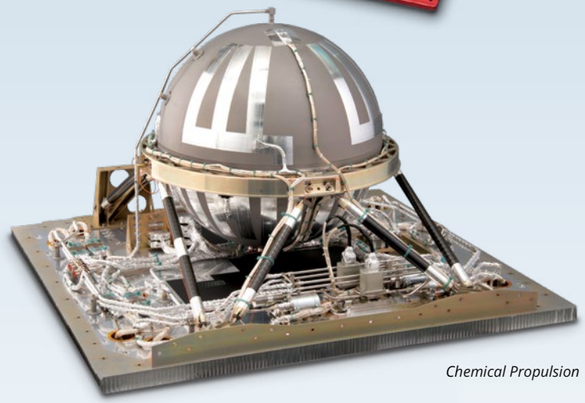
- In-house hot fire testing
- Investment in additive technology in thruster design
- Research and Development capabilities
- Modeling and simulation
- Environmental testing

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

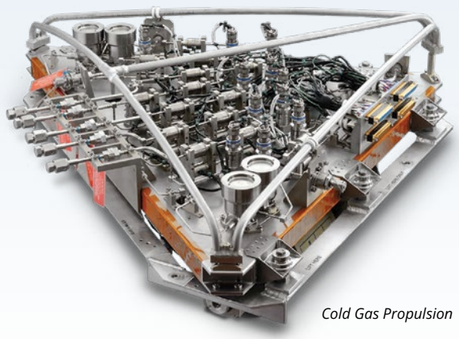
- Monopropellant and bipropellant chemical propulsion
- Cold gas propulsion
- Green propulsion
- Electric propulsion



Electric Propulsion Feed System

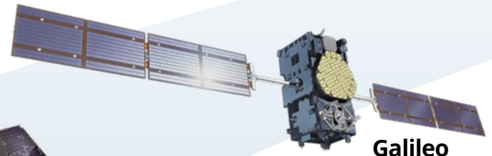


Chemical Propulsion



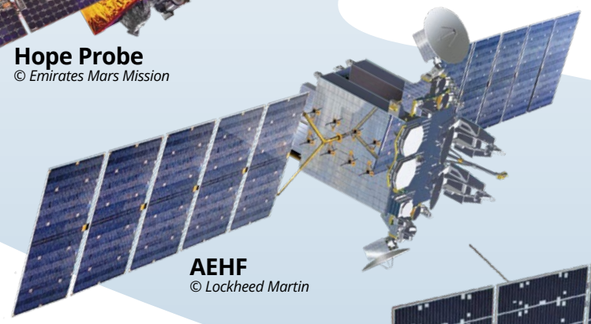
Cold Gas Propulsion

SPACECRAFT PROPULSION EXPERIENCE

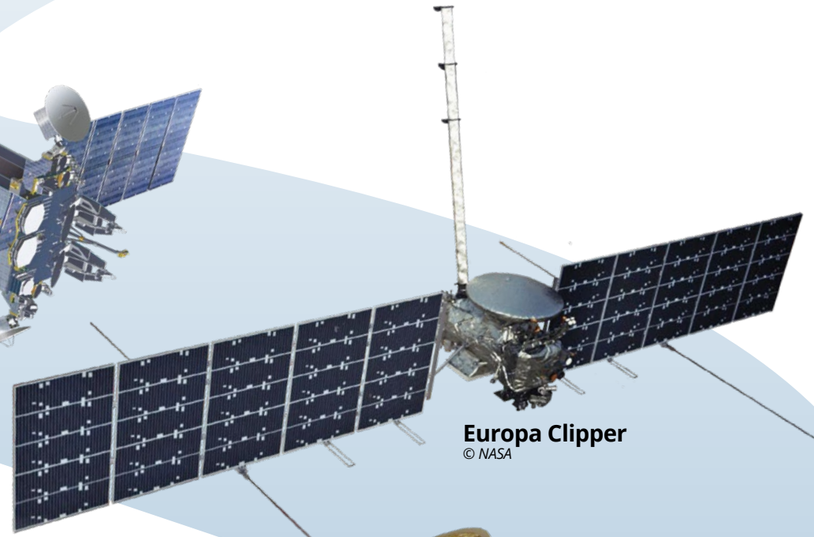


Galileo
© ESA

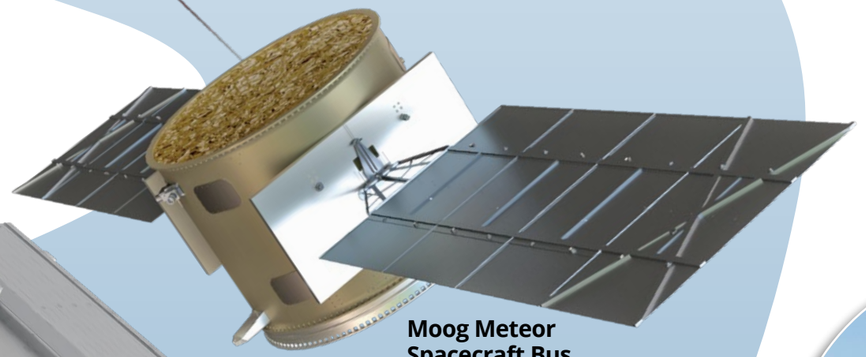
Hope Probe
© Emirates Mars Mission



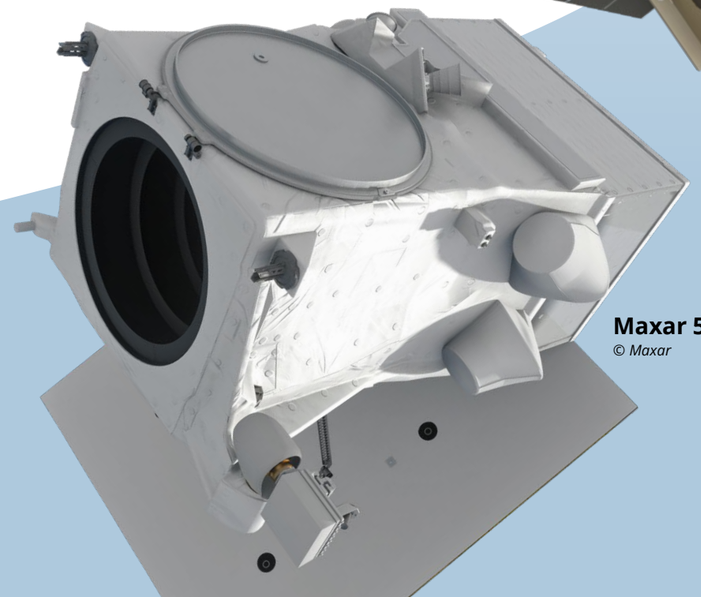
AEHF
© Lockheed Martin



Europa Clipper
© NASA



Moog Meteor Spacecraft Bus



Maxar 500
© Maxar

LAUNCH VEHICLE PROPULSION EXPERIENCE

SLS
© NASA/Aubrey Gemignani

Atlas
© ULA

Vega
© ESA

Antares
© Orbital

Vulcan
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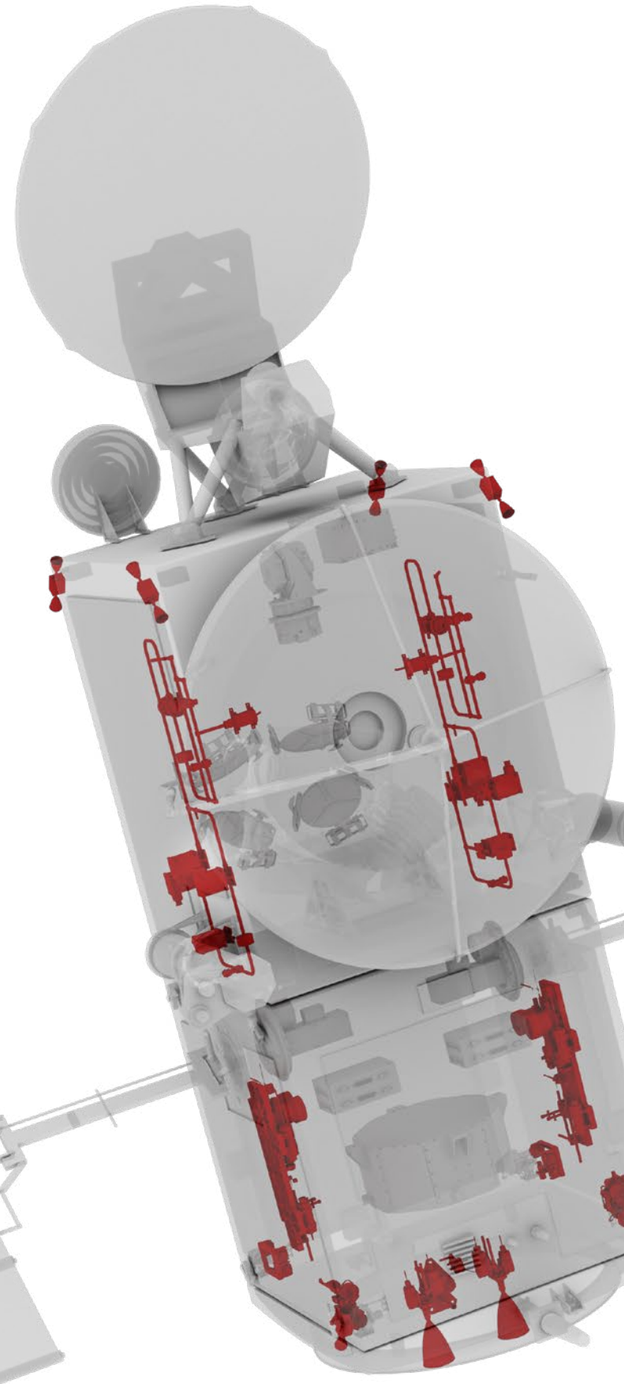
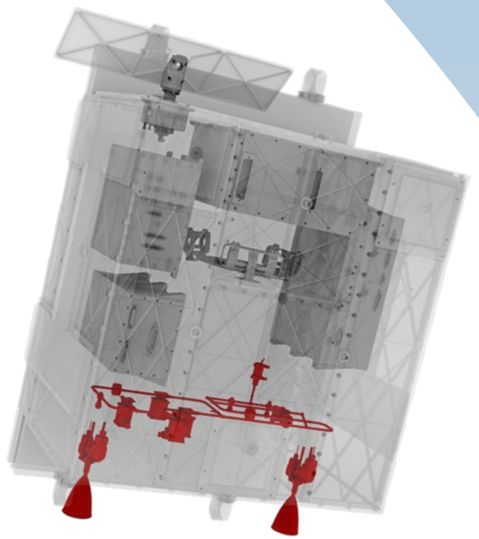
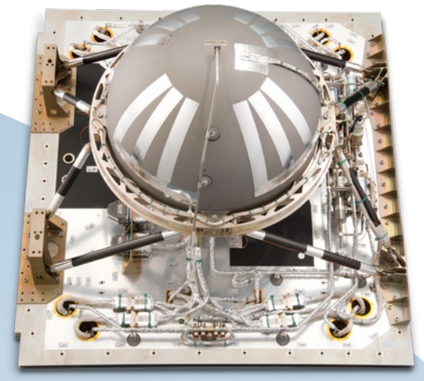
SPACECRAFT PROPULSION

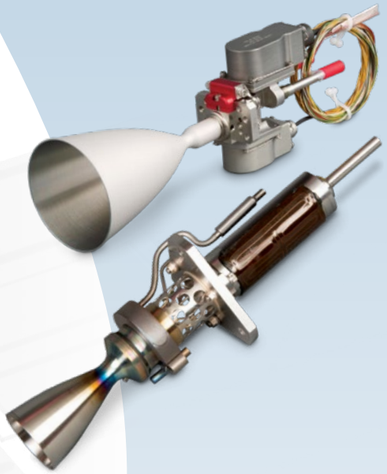




INTEGRATED PROPULSION SYSTEMS AND SUBSYSTEMS

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. They are used on direct-to-customer applications, as well as integrated on Moog's own space vehicles.



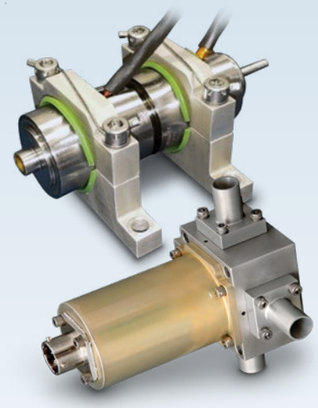


MONOPROPELLANT AND BIPROPELLANT THRUSTERS

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

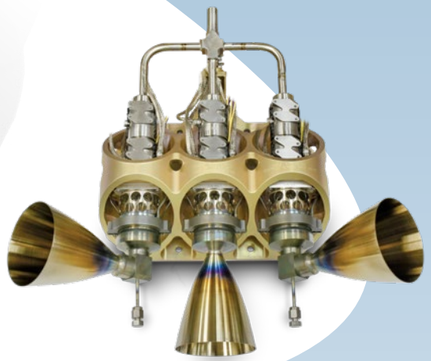
Our cold gas thruster designs are compatible with inert gases to support thrust control and momentum transfer applications. Our thrusters range from <1N to 645N. They have been used on satellites, deep space missions, and untethered space walks. We have also demonstrated this technology in support of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



VALVES AND REGULATORS

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

LAUNCH VEHICLES AND MISSILE PROPULSION

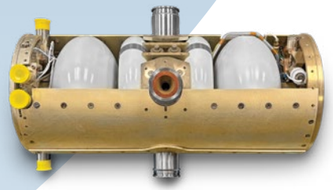


PROPULSION SUBSYSTEMS

Subsystems on launch vehicles, missiles, and missile defense systems provide control and isolation for propellants. Components are built/manufactured, tested, and integrated into a subsystem for delivery to the customer. Moog also offers integration of subsystems onto customer platforms.

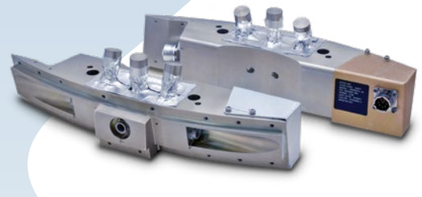
DIVERT AND ATTITUDE CONTROL SYSTEMS

Today's threats require sophisticated ballistic missile defense systems. Moog fluid components and engines are integrated into propulsive divert and attitude control systems (DACS) to provide the necessary trajectory adjustments of a kill vehicle to successfully intercept incoming threats.



ATTITUDE AND ROLL CONTROL THRUSTERS

Moog provides attitude and roll control thrusters for several propellant types: 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.

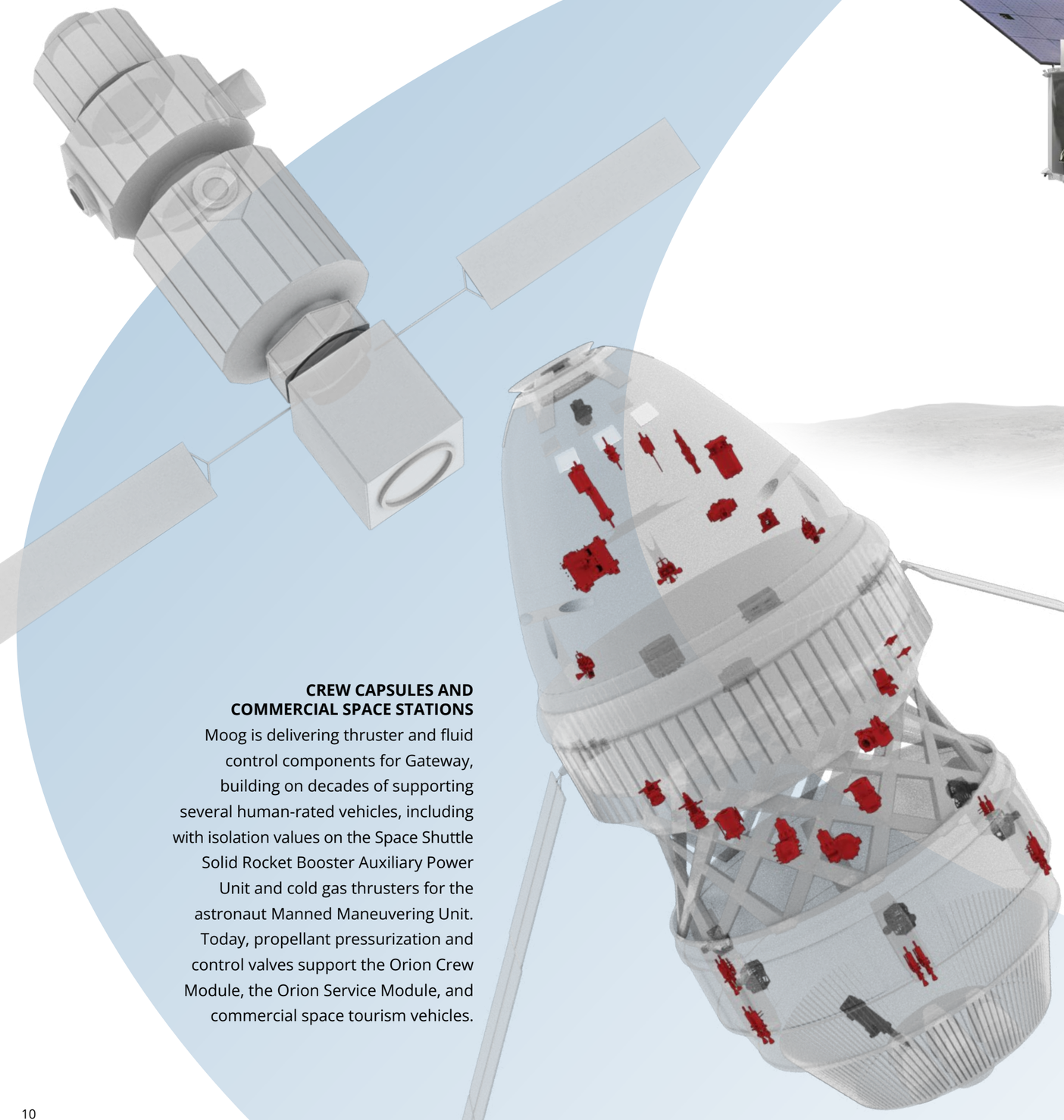
FLUID TRANSFER COUPLINGS

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.

CREWED AND PLANETARY EXPLORATION



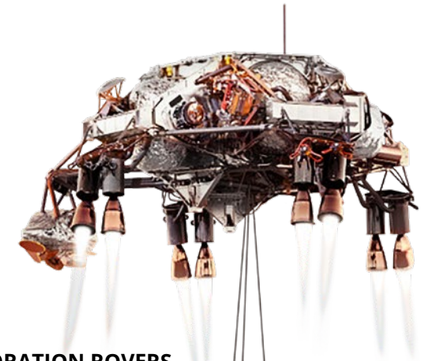
CREW CAPSULES AND COMMERCIAL SPACE STATIONS

Moog is delivering thruster and fluid control components for Gateway, building on decades of supporting several human-rated vehicles, including with isolation values on the Space 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

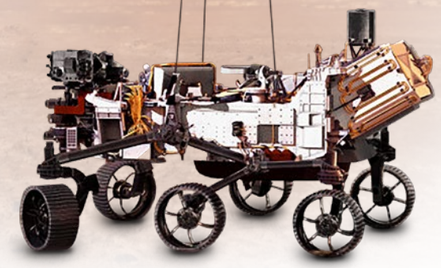
ASTEROID SAMPLE COLLECTION

Our latch valves and fill-and-drain valves continue to support the hydrazine propulsion system on OSIRIS-REx (completed), now OSIRIS-APEX. OSIRIS-REx was 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-APEX 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 mission. Most recently, we supported all stages of the Perseverence Mission, including thrusters and throttle valve assemblies used during the cruise, entry, descent, and landing phases.



Perseverance Rover – NASA

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