FUTEK
ADVANCED SENSOR TECHNOLOGY, INC.

FAILURE IS NOT AN OPTION

FUTEK'S AEROSPACE PORTFOLIO

Load Cells
Torque Sensors
Pressure Sensors
Force Sensors
Multi-Axis Sensors
Instruments
Software
Calibration Services

Sensor Solutions Source

www.futek.com

FUTEK's space collaborations with partners such as NASA, Raytheon, MIT, Lockheed Martin, and JPL have allowed us to support some of the most important scientific achievements of our time. As an ISO9001-2008 accredited, AS9100 compliant, ANSI-Z540 certified, and ISO 17025 A2LA approved design and manufacturing house, FUTEK has had the privilege to develop new technologies to withstand the unexpected environments that space presents. We possess the capabilities needed to develop load cells, torque sensors, and multi-axial sensors that meet the complex requirements of cryogenic and vacuum environments. Here, we have assembled snapshots of some of the most significant ventures.

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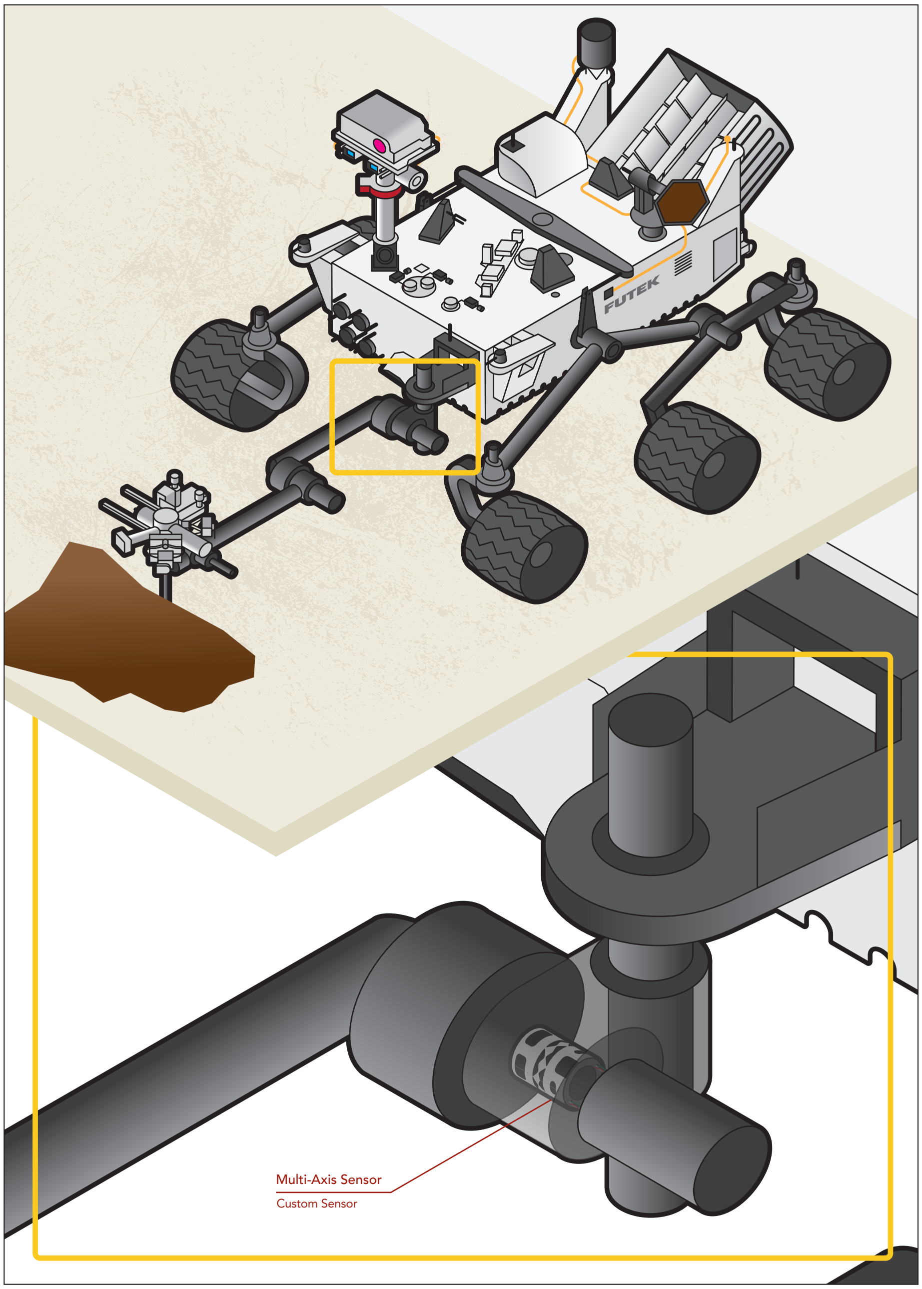
APPLICATION 701

NASA Mars Rover



The NASA/JPL rover Curiosity. landed on Mars in August 2012 with the mission to explore Martian terrain. FUTEK developed two unique sensors for the project that operate around the clock, within temperature cycles from 23°F to as low as -124°F.

The car-size rover uses a 7-foot-long robotic arm to drill into the surface and acquire rock, soil, and sediment samples for onboard analysis. FUTEK's custom load and multi-axial sensors monitor the torsion and load applied to the drilling arm and its robotic maneuvers. In addition, they measure and monitor the force applied to the drill bit. The input is synced directly to a continual feedback system, which notifies the rover when maximum force is being applied.

As Curiosity continues to explore the surface of Mars and send back extraordinary science from its landscape, it has outperformed NASA's original expectations. So have FUTEK's custom sensors, which have come to play an even more vital role than originally anticipated. When the rover's original drill mechanism failed, the JPL team found a way to configure the two FUTEK sensors to stabilize and control the drilling so the sample collection and analysis could resume.

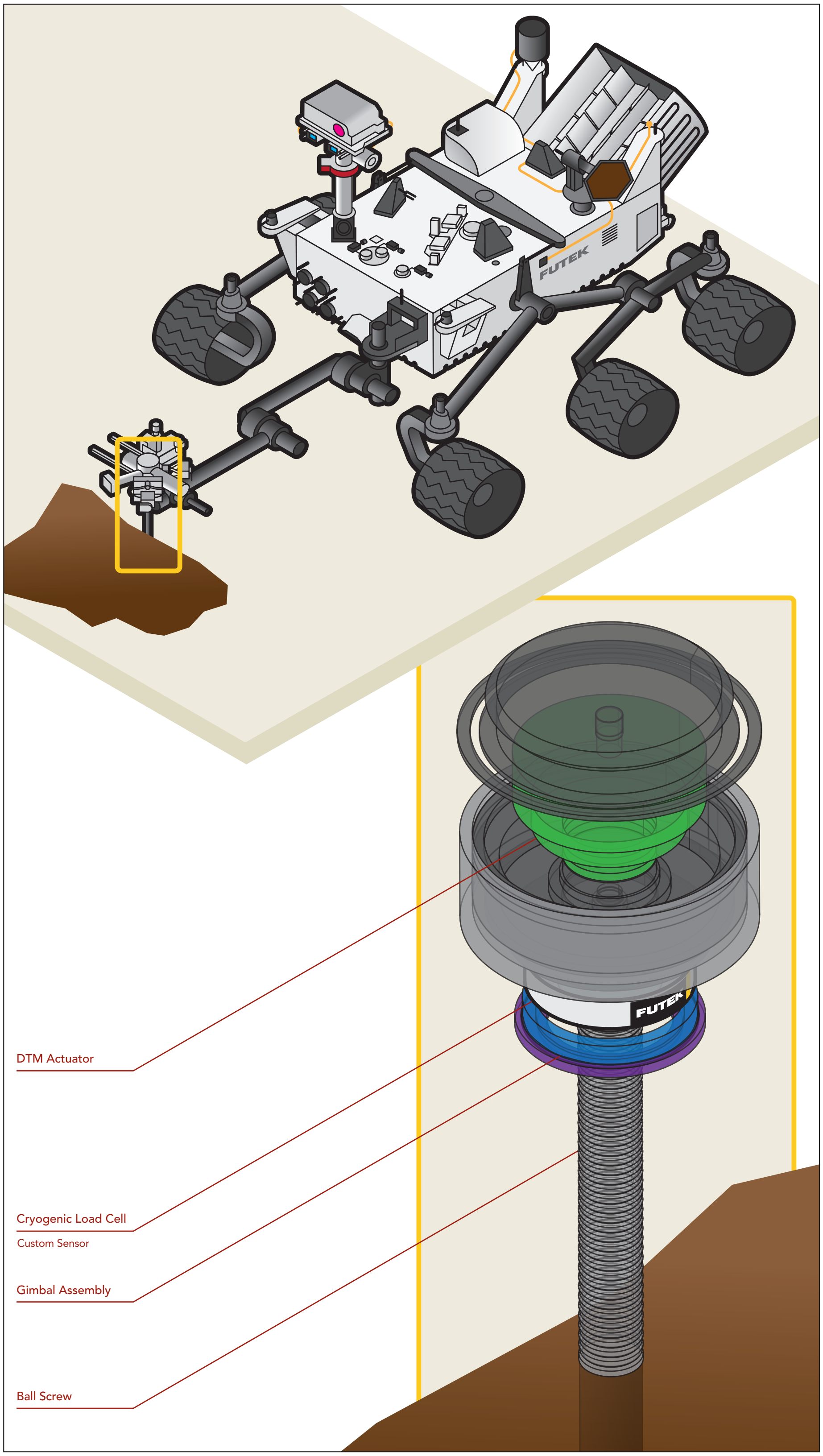
CRYOGENIC MULTI-AXIAL LOAD AND TORSION SENSOR

FUTEK developed a custom cryogenic multi-axial sensor with capabilities to measure both torque and force in the rover's drilling arm.

- Measures the torsion and force applied while the arm operates
- Provides feedback to the operating device identifying the levels of torsion and force
- Alerts the rover if over-exertion on the arm occurs

APPLICATION 126

NASA Mars Rover



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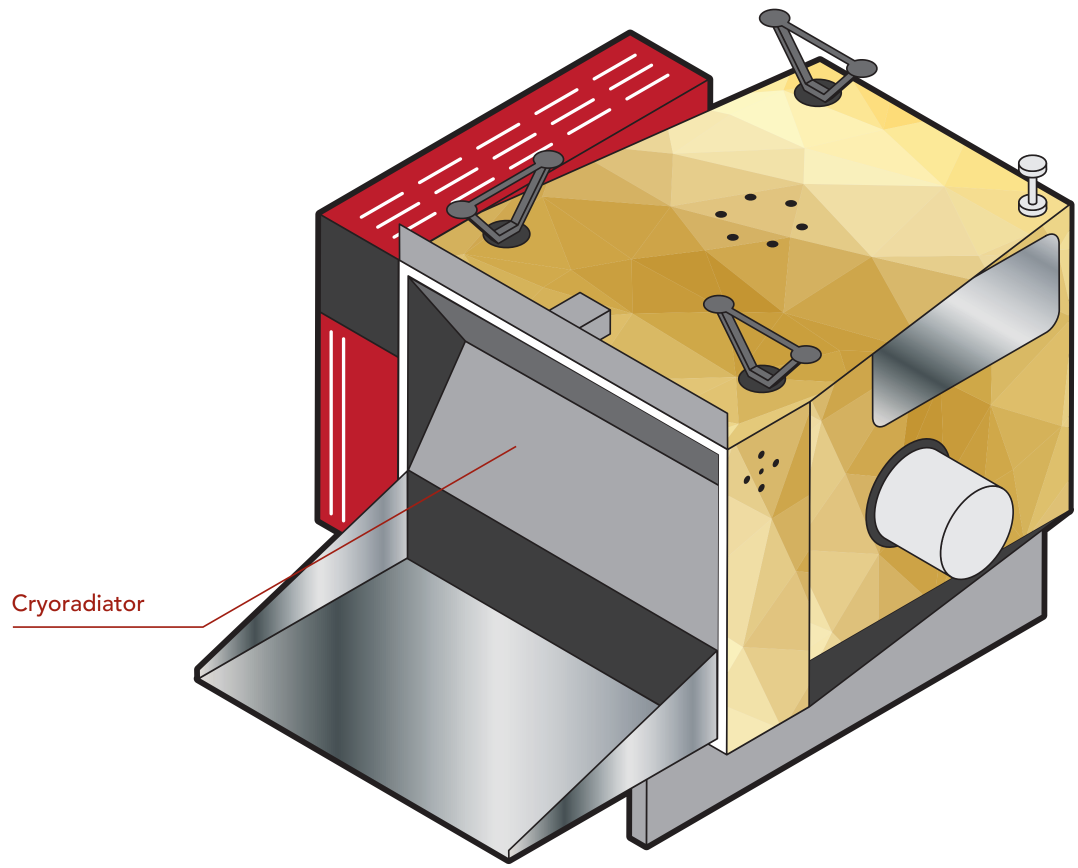
CRYOGENIC LOAD CELL SENSOR

This cryogenic dual-bridge thru-hole load cell sits within the arm's drilling mechanism in order to supervise the precision and force used to drill directly into the Martian surface.

- Measures the forces of the drill bit at a high level of accuracy and resolution that a current controlled motor drive system cannot achieve.
- The dual-bridge allows redundancy in the system, reducing the risk of the system becoming inoperable in the extreme conditions

APPLICATION 127

NASA/Raytheon Visible Infrared Imager Radiometer Suite (VIIRS)



The Visible Infrared Imaging Radiometer Suite (VIIRS), developed by Raytheon Technologies, is one of the key instruments onboard NASA's Suomi National Polar-Orbiting Partnership (Suomi NPP) spacecraft, the first satellite mission to address the challenge of acquiring a wide range of environmental measurements for scientific study while simultaneously preparing to address operational requirements for weather forecasting. The VIIRS empowers operational environmental monitoring and numerical weather forecasting, with 22 imaging and radiometric bands covering wavelengths from 0.41 to 12.5 microns, providing the sensor data records for more than twenty environmental data records including clouds, sea surface temperature, ocean color, polar wind, vegetation fraction, aerosol, fire, snow and ice, vegetation, and other applications.

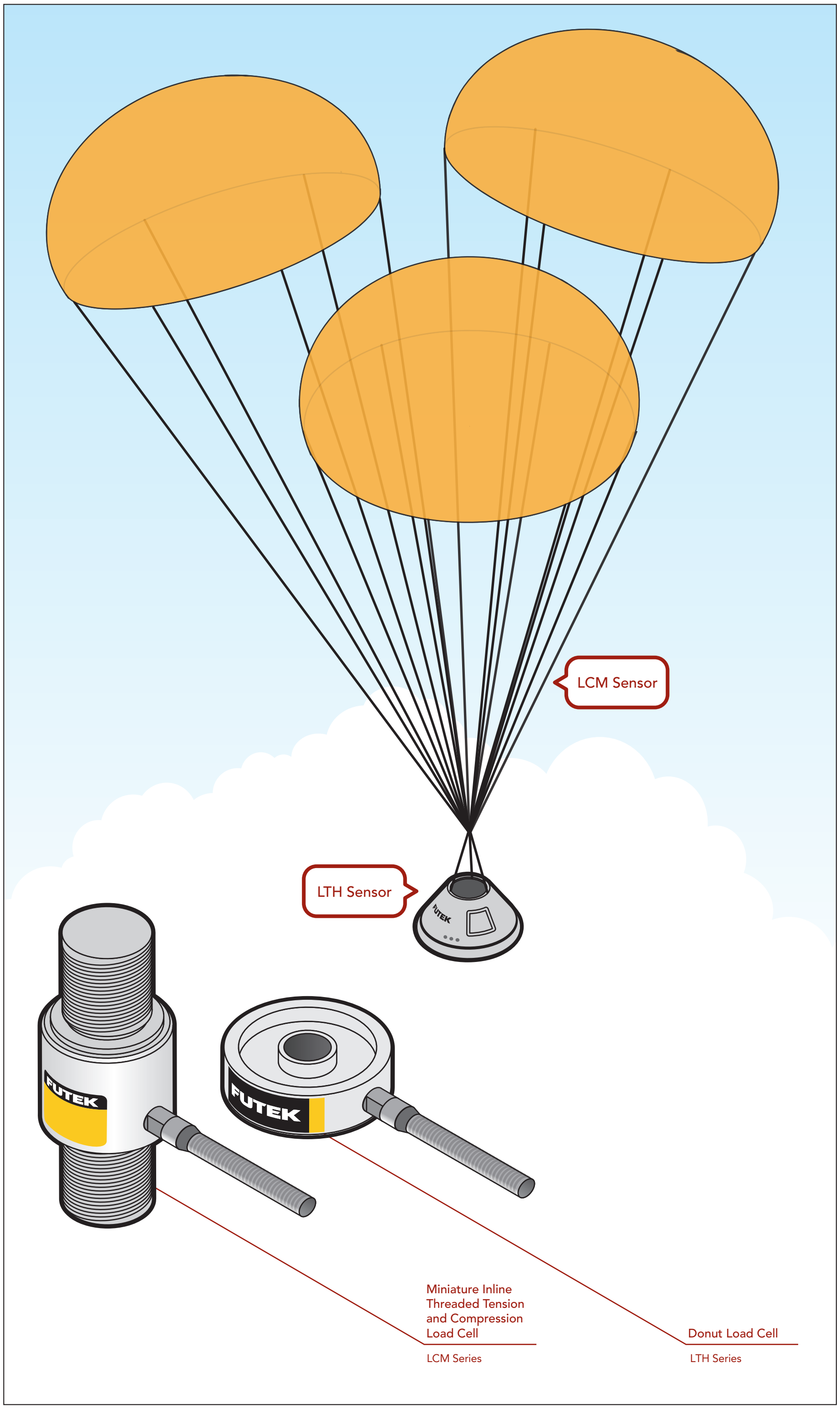
FUTEK was commissioned by Raytheon to develop two custom cryogenic load cells to monitor the force applied to the cryo-radiator. The sensors were used to monitor the assembly and testing of the Cryoradiator system. As the system was assembled, moved, and tested they had to maintain the system in perfect alignment and position. The two sensors performed this task within the VIIRS instrument while the satellite was in orbit. One load cell was applied to measure loads solely in the intermediate stages, while the other monitored loads in sub-zero temperature stages. Special engineering and manufacturing process and testing criteria was critical as the sensor stability was extremely important. went into the construction of these sensors, as they needed to fulfill several complex requirements:

CRYOGENIC LOAD CELLS

- Operational in cryogenic temperatures up to -300°F (-184°C),
- Dual bridge
- Vacuum rated
- Shock and vibration resistant

APPLICATION 136

NASA's Orion Multi-Purpose Crew Vehicle



The Orion Multi-Purpose Crew Vehicle (MPCV) is a spacecraft that will usher in a new era of space exploration by taking humans further into space than they have ever gone before. During deep-space missions Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during the space travel, and provide safe re-entry from deep space return velocities. Orion will launch on NASA's new heavy-lift rocket, the Space Launch System.

FUTEK collaborated with NASA to develop safety-testing sensors for Orion's parachute system.

Like all shuttles returning to the Earth's surface,a parachute is needed to ease its entry speed. FUTEK designed two custom solutions to measure the force of the payload applied against the parachute system for the re-entry and in-mission abort simulations. The precision of these particular load cells was highly critical, as was their endurance. Both solution options provided NASA's test engineers with highly accurate testing data.

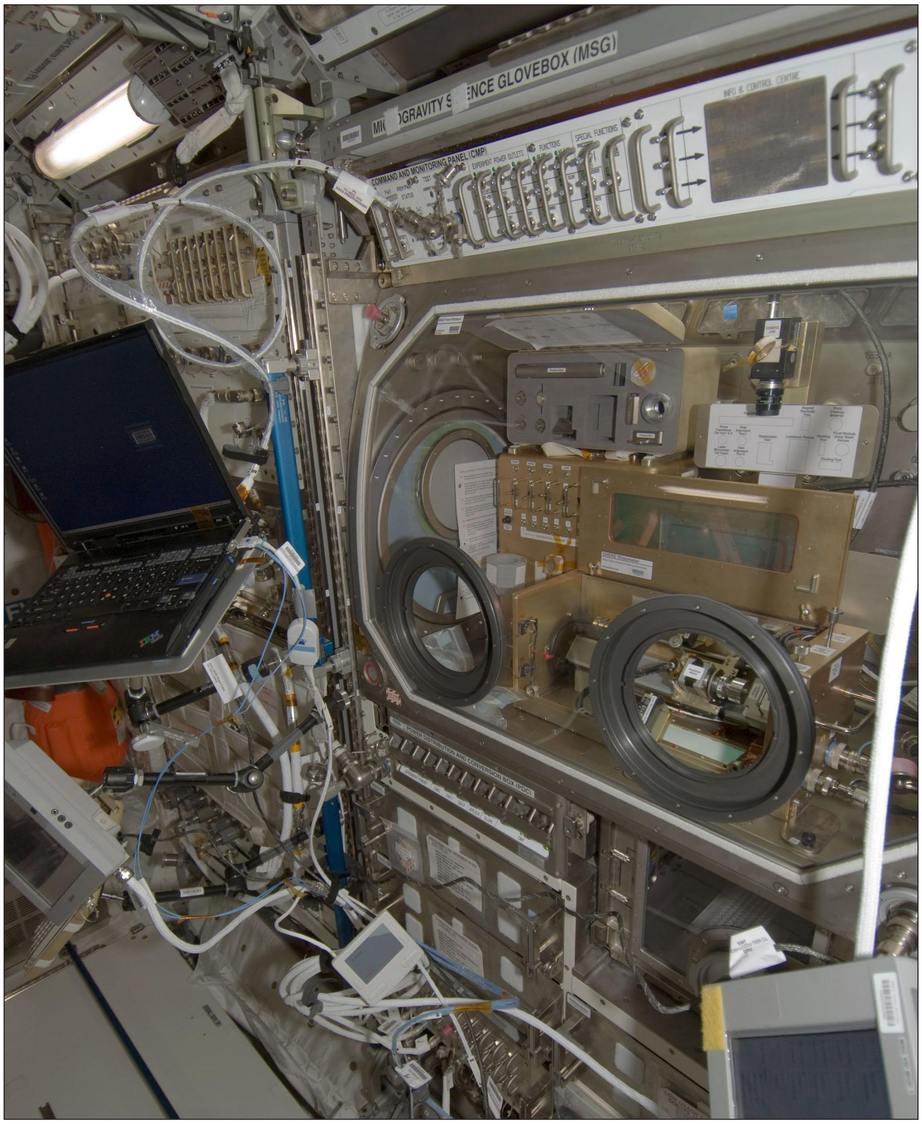
SOLUTION 1: MINIATURE THREADED IN LINE LOAD CELL (LCM SERIES)

FUTEK's Miniature Threaded In Line Load Cell is installed between the cables, creating a wire tension measurement application. The material selection and robust design of these sensors extends their use to demanding applications. In this instance, the sensor will be exposed to a considerable temperature range and impact during landing, making shock load resistance and robustness extremely important capabilities.

SOLUTION 2: DONUT/THRU HOLE LOAD CELL (LTH SERIES)

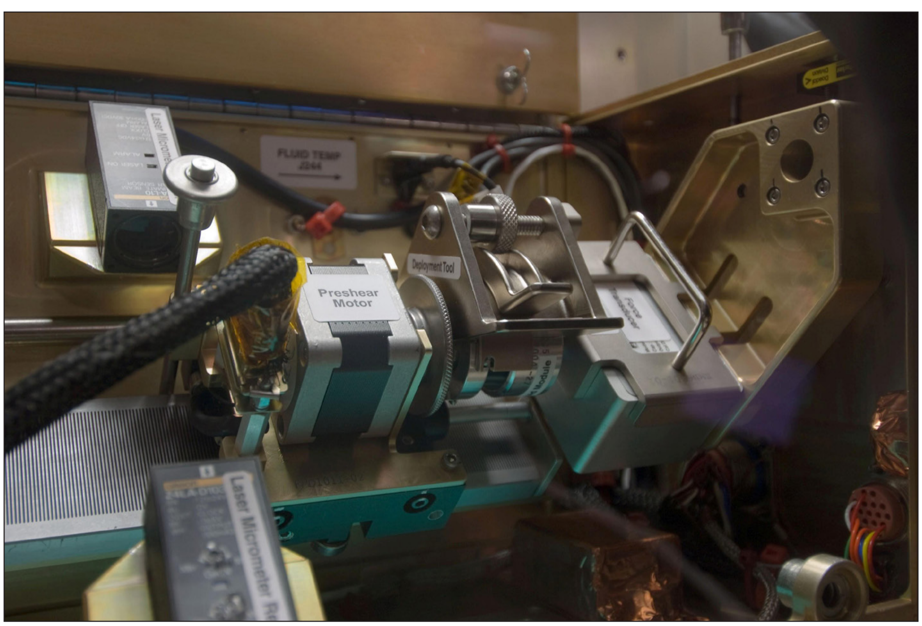
The Donut/Thru Hole Load Cells are mounted at the base of the deployment system to measure the immediate and continuous force of the payload applied to the parachute cables.

NASA's Shear History Extension Rheology Experiment (SHERE)

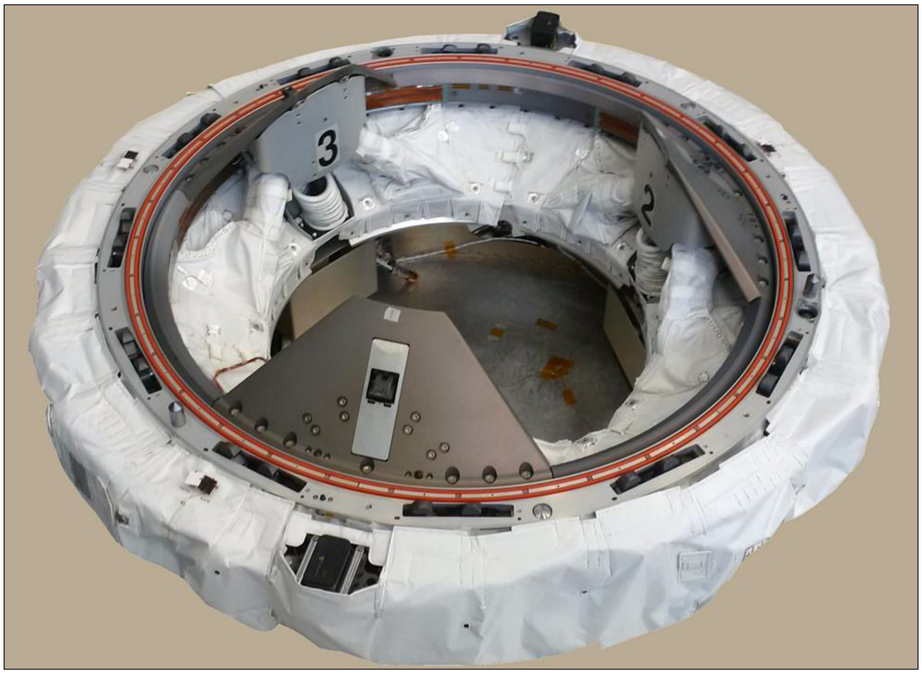


FUTEK participated alongside NASA and MIT in a joint venture to create the Shere History Extensional Rheology Experiment (SHERE). This program was designed to examine the stress and strain of polymer fluid in microgravity. The purpose of the study was to provide data that would help the development of in-situ fabrication and repair technology, a critical element in the evolution of autonomous exploration capability.

SHERE is designed to fly in the Microgravity Science Glovebox (MSG) on the International Space Station (ISS). The main SHERE hardware consists of the interface box, rheometer, camera arm, cabling, keyboard, and tool box. FUTEK developed a 10 Kilo-Dyne load cell to measure these fluid viscosity forces. The sensor had to meet unique requirements such as measuring in dynes range, surviving the high Gs generated from lift-off, and being able to dampen extremely fast after performing the measurement.



NASA International Low Impact Docking System (iLIDS)



The program known as the International Low Impact Docking System (iLIDS) required several quad-bridge tension and compression miniature load cells to detect, guide, and dock incoming space vehicles. These load cells were to follow specific space and flight standards, ensuring their conformity with various forms of spacecraft.

The measurement was to give haptic feedback to the docking ring to allow for self aligning and low impact during contact from the space capsule to the ISS. The sensor had to have a quad bridge, for redundancy and voting between System A and B with a miniature package size.

ANSI Z540-1 | ISO 9001 | ISO 17025 | ISO 13485 | RoHS | U.S. Manufacturer

Drawing number: XX0000

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