FORCE MEASUREMENT SOLUTIONS

CASE STUDY

Force Measurement for Space Travel

About

Space travel is one of the most intriguing pursuits in modern culture and enormous investments have been made to reach the dream of navigating the final frontier. From government to private entities such as SpaceX and Blue Origin, the colonization of celestial bodies is becoming a real possibility, maybe even in our lifetime. However, what most people don't think about when discussing the journey into space is the vast amount of different technologies that go into developing a spacecraft. This case study provides insight into how force measurement and Interface play a large role in the development of spacecrafts. It includes a brief overview of the customer challenge and examples of Interface solutions used to optimize spacecraft and other aerospace product designs.

Challenge

There are hundreds of thousands of moving parts in the space industry that need to be optimized for a successful launch. From the thrust of a rocket engine to the structural integrity of the craft's landing gear, the hardware goes through test after test to ensure that everything is built to specifications, performs at a high level, and is reliable over time. Any tiny miscalculation or error in the design, manufacturing and testing of this equipment can become costly, and more importantly, unsafe to the astronauts and crew.

One of the key test processes that occur during the development of a spaceship is force measurement testing. Companies in the aerospace industry involved in space travel must understand various aspects of the force, compression, torque, and tension that materials and components used in the design of a spacecraft can withstand or output. For instance, thrust is a critical factor in providing enough speed to launch a vehicle out of the earth's atmosphere. Data on the power of a rocket engine's thrust is calculated with force sensors. Another design consideration in a spacecraft is the structural integrity of the fuselage and wings. These are also pieces of hardware that can also be analyzed using force measurement devices.

Ultimately, optimizing a spacecraft's design involves testing a lot of moving parts that all interact differently when introduced to stressors during the launch sequence. Companies in the aerospace industry have turned to force measurement to gather accurate data on these systems, processes, and materials.

1200 High Capacity LowProfile™ Load Cell

1200 Standard Precision LowProfile™ Load Cell

1100 Ultra Precision LowProfile™ Load Cell

9870 High Speed High Performance TEDS Ready Indicator

Interface Solutions

Interface offers a wide variety of load cells, torque transducers, load pins, and load shackles, and digital instrumentation to collect data and improve the design, manufacturing, and most importantly, the testing process for spacecrafts. Interface's work in space is on display in testing labs, manufacturing facilities and even launch sites worldwide. Included below are a few examples of real applications of force measurement in space:

Structural Testing

Structural tests are critical to the launch process because the craft's core components, such as the liquid hydrogen and oxygen tanks, wings, and fuselage, must withstand launch loads of up to nine million pounds of force (lbf). Recently, NASA's Space Launch System (SLS) used Interface load cells to measure the core stage of the rocket. This particular core stage is one of the largest ever built at 27 feet in diameter and more than 200 feet tall.

To perform the structural test, Interface supplied its 1200 High Capacity Standard Precision LowProfile™ Load Cells, which were attached to hydraulic cylinders at various locations along the rocket test stand to provide precision test forces. Strain gauges were also bonded to the rocket structure surface and connected to a data acquisition system for stress analysis. NASA engineers were able to measure loads applied at various areas on the rocket structure, verifying the structural performance under simulated launch conditions.

Thrust Testing

A rocket that is fully fueled and ready for launch can weigh up to five million pounds. Therefore, the force necessary to lift the rocket out of the earth's atmosphere is immense. There are several other factors working against the rocket which need to be compensated for when adjusting thrust force such as drag. Interface has supplied load cells to many aerospace customers to test force and other contributing factors for lifting a rocket into space. These load cells work by being installed underneath a test plate which the rocket engine will sit on. As the engine thrusts, the load cells will calculate the force output of the engine in real-time. This data is used to optimize the engine to determine how much thrust force is needed based on the spacecraft's total weight and the calculated drag at liftoff.

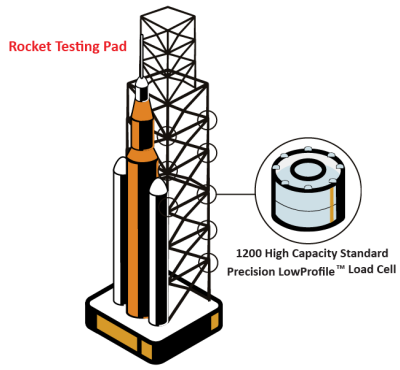
Force Gravity Testing

Force measurement tools also serve many purposes outside of spacecraft testing in the aerospace industry. Interface was involved in a unique application of force measurement with a customer that wanted to develop a system to provide a full range of natural motion for a realistic simulation of reduced gravity environments. The system would be used to simulate weightlessness so astronauts' crews could learn how to handle microgravity activities, including walking, running, and jumping. The system could also be used for surface operation studies, suit and vehicle development, robotic development, and mass handling studies.

In this application, Interface supplied a Model 1100 Series Load Cell, which was installed in-line with a steel support cable to actively measure the vertical load on the system. A control system was then utilized, (which includes a Model 9870 High Speed High Performance TEDS Ready Indicator), to monitor the load cell output and continuously offload a portion of a human or robotic payload weight during all dynamic motions. Using precise feedback from the load cell, the control system commanded a motor to raise or lower the subject to maintain a constant offload force. During the simulation, the system actively compensated for the subject's movement to accurately reproduce a microgravity environment.

Learn More

The pursuit of space is finding unique and innovative ways to traverse the star, carry more payload, and even find new places to inhabit. Hardware testing will continue to play a critical role in optimizing and verifying this new technology, and force measurement is a significant part of this process. Interface has many systems and products available for aerospace applications. The company has been a trusted partner to some of the world's largest space OEMs since the company's advent more than half a century ago.



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7418 East Helm Drive, Scottsdale, AZ 85260 ▪ **480.948.5555** ▪ **InterfaceForce.com**