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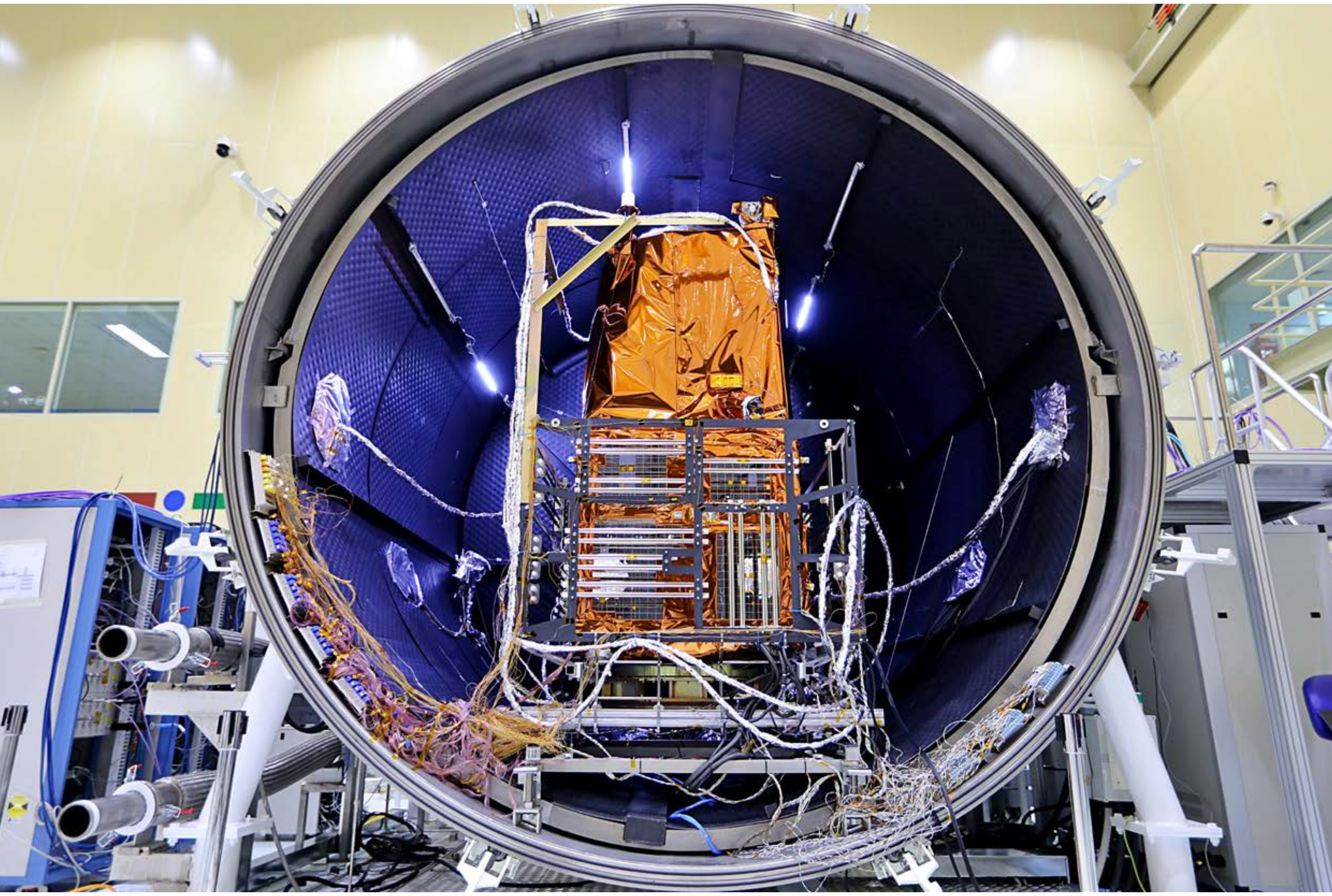
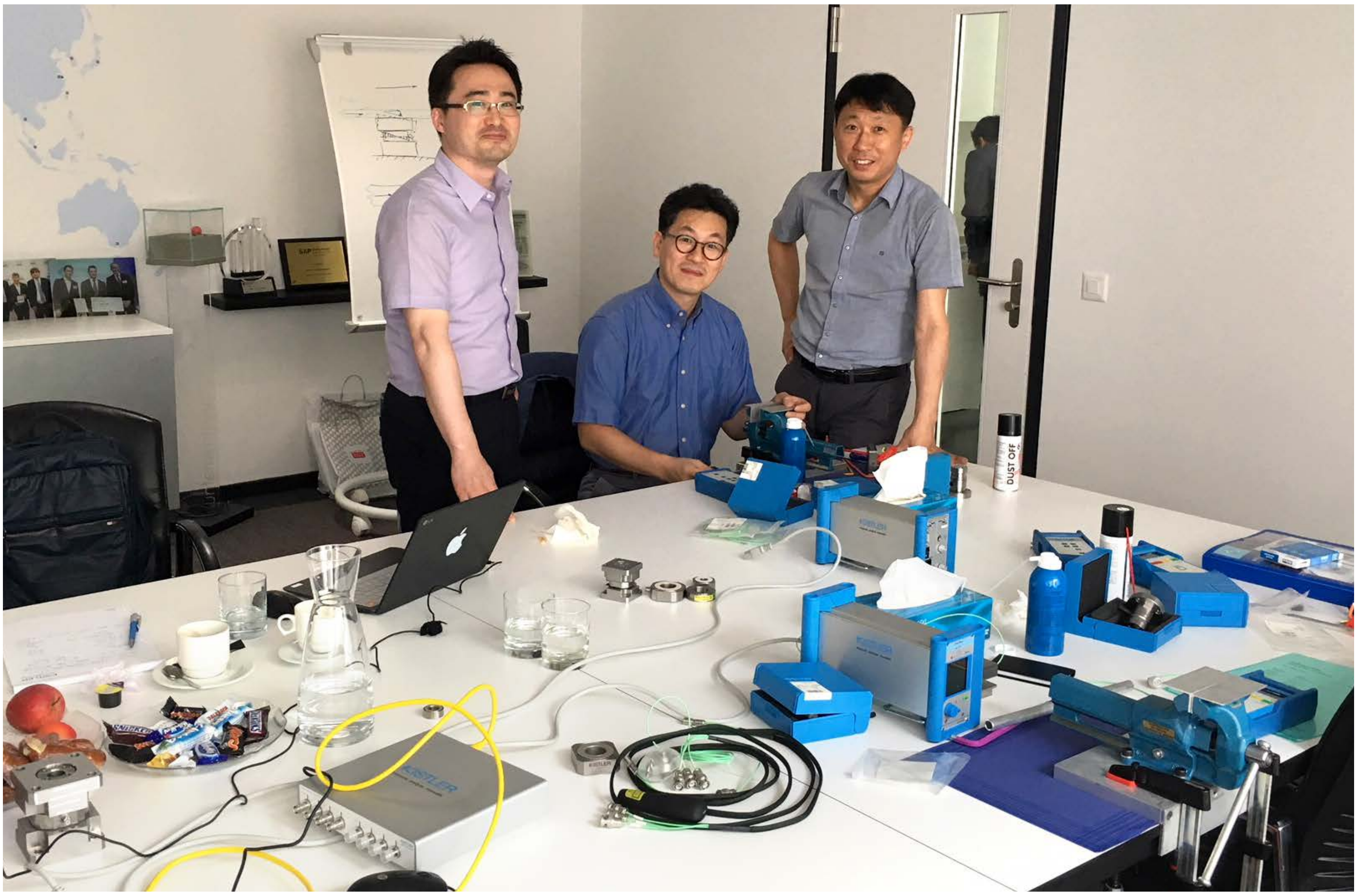


More reliable testing

How Kistler is supporting South Korea's space research and development

KARI

Korea Aerospace Research Institute



From right to left: development engineers Sung-Hyun Woo, Ph.D., and Jong-Min Im of the Korea Aerospace Research Institute (KARI) working with Seong-Oh Lee of Kistler on the measuring chain for satellite vibration tests.

The Korea Aerospace Research Institute relies on measurement technology from Kistler to perform force-limited vibration tests on satellites. 24 force sensors – aligned in a ring structure and connected to LabAmp charge amplifiers and data acquisition units – provide the basis for integrated acceleration control to prevent damage caused by overtesting.

South Korea is one of the young member nations in the space exploration community. Activities started back in 1989, when the Korea Aerospace Research Institute (KARI) was established. Located in the central city of Daejeon, KARI is part of the Daedeok Innopolis science and research cluster where over 20,000 researchers are at work. After developing its first rockets for space vehicles in the 1990s, KARI currently focuses on developing smart unmanned aerial vehicles (UAVs), satellite programs, and – in collaboration with NASA – lunar exploration.

In an ongoing project launched in June 2018, engineers at KARI have pursued the goal of implementing an infrastructure to perform flexible vibration tests for large payloads. Force-limited vibration testing (FLVT) is a proven procedure for simulating the mechanical stresses caused by vibrations during the launch and in flight. The UUT (unit under test) is placed on a shaker that can trigger defined and controlled excitation of masses. It is important to prevent overtesting, which could possibly lead to severe damage or even destruction of the UUT: to achieve this, acceleration levels are often controlled with additional force sensors. "This method has proven more sensitive, reliable and practical than monitoring acceleration only," according to Sung-Hyun Woo, Director and Principal Researcher in the Space Environment Test Division at KARI. "Our goal was to create a control that automatically notches the excitation in response to the feedback from the force sensors." Notching is the technical term for a reduction of acceleration input in narrow frequency bands, and it is usually applied in frequency bands where a test object has resonances.

Reliable data and fast processing enable automation

The KARI engineers' efforts were ultimately rewarded with success. They implemented an FPGA (field-programmable gate array) that is capable of processing calculations simultaneously and independently of the number of operations. Im comments: "The resulting time for the complete force-moment calculation is now only 0.12 ms, in three loops of 0.04 ms. Many parameters

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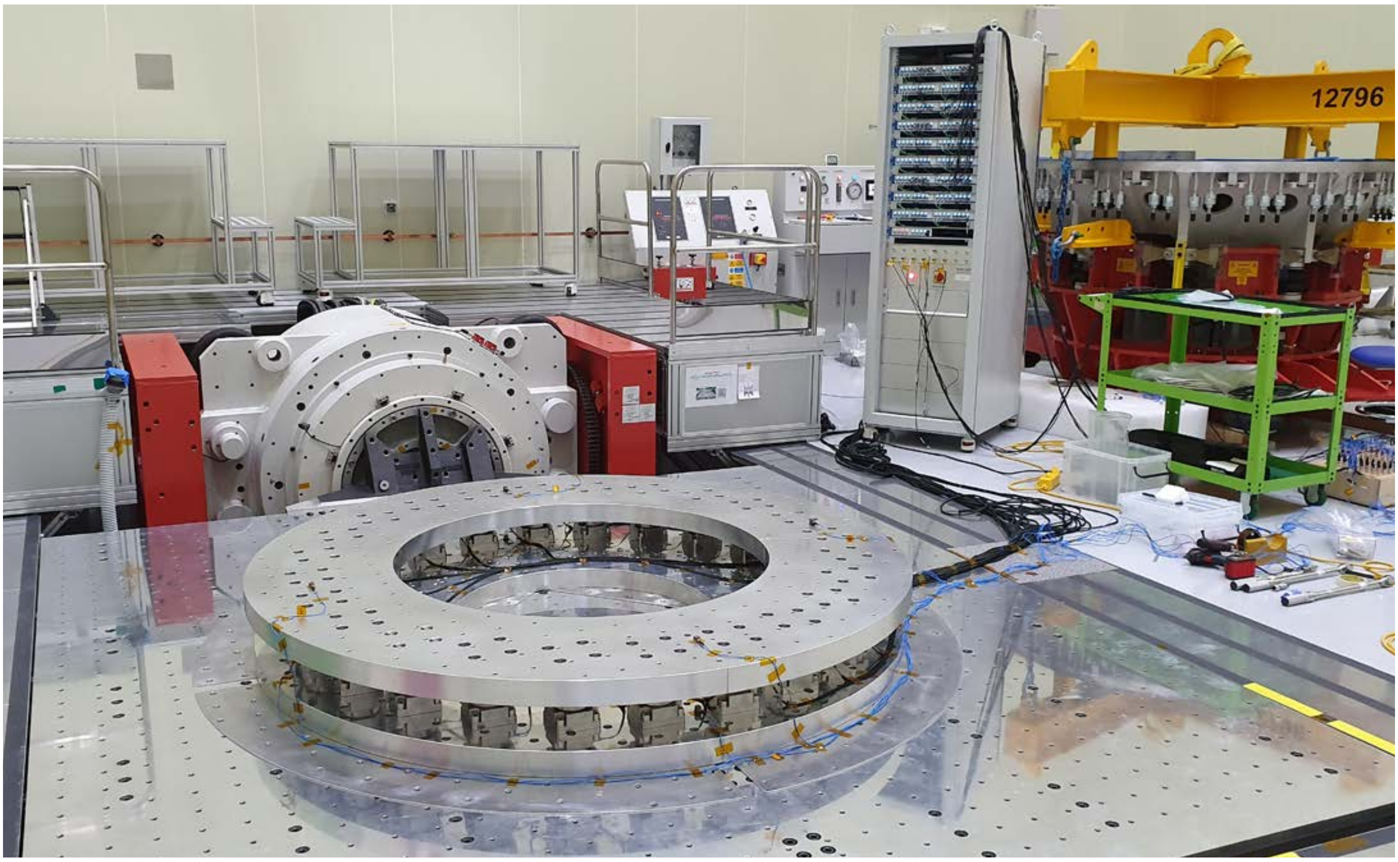
Sung-Hyun Woo, Director and Principal Researcher in the Space Environment Test Division at Korea Aerospace Research Institute (KARI)



Measurement equipment from Kistler in a ring structure for FLVT.

and variables had to be considered before the interface between force measurement and acceleration control was established – but finally, we managed it!"

The next step was to perform a comparative test on the new control. As Im explains: "We wanted to verify whether our system really is better than a manual procedure, so we carried out a lateral vibration test with the structure in place, and with high moments acting on the base of the satellite dummy."
The test clearly showed that the system performed well. Thanks to automatic notching – which decreased the acceleration inputs from 0.15 to 0.03 g in the resonance frequency range – the moment limit of 60 kNm was not exceeded. Under manual control, on the other hand, higher values of up to 71 kNm occurred, leading to significant overtesting. The KARI engineers then went on to perform force-limited vibration tests with integrated automatic notching and limits of up to 300 kNm. The results were convincing, so they are now ready to go ahead and apply the new system to real satellites.

"Kistler has given us incredible support throughout the whole project – in terms of product quality and data reliability as well as consulting. They assisted us by sharing their vast knowledge of piezoelectric measuring chains, and they helped us to get everything going," Sung-Hyun Woo sums up. "We also see them as a valuable partner for future projects. As well as force sensors and DAQ systems, we could benefit from Kistler's accelerometers in upcoming projects. And last but not least, another major advantage for us is the local technical support we get from Kistler Korea whenever we need it."

Piezoelectric force sensors are based on the piezoelectric measurement principle. They are suitable for measuring (highly) dynamic and quasistatic forces. The force acting on the quartz built into the sensor generates a proportional charge at the signal output. A downstream charge amplifier converts this into a process signal that can be evaluated. One of the special advantages of the piezoelectric measurement element is its constant measurement accuracy over a wide measuring range: thus, it is possible to use a very large sensor to measure the smallest of forces – with constant measurement accuracy. Piezoelectric sensors are also characterized by a high level of overload protection, eliminating the need for protective measures, especially in low measuring ranges.

The 9377C force sensor from Kistler is a piezoelectric precalibrated triaxial transducer for forces up to 150 kN.

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