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Deep dive into the distant past

Kistler supplied NASA with sensor solutions for testing the James Webb Space Telescope

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NASA's Webb Reveals Cosmic Cliffs, Glittering Landscape of Star Birth. Behind the curtain of dust and gas in these "Cosmic Cliffs" are previously hidden baby stars, now uncovered by Webb.

For one of the most ambitious and complex space exploration projects in human history, the James Webb Space Telescope, NASA relied on Kistler to supply measurement technology for FLVT (Force Limited Vibration Testing) and mechanical testing. Triaxial force transducers and ultra-low temperature accelerometers were used in the extensive test procedures for the mirror and the unit carrying the scientific instruments.

When Italian astronomer Galileo Galilei pointed the world's earliest telescope at the moon in 1610, he became the first person in history to see its craters and mountains. Four hundred years later, NASA is collaborating with the Canadian and European Space Agencies on the largest and most complex space telescope ever constructed: the James Webb Space Telescope (JWST, or just "Webb" for short). In the unfolded state, the 18 hexagonal segments of Webb's primary mirror is 22 ft tall and 20 ft wide.

Because of this extraordinary size, Webb was packed into the Ariane 5 rocket in its folded state for the launch from Kourou in French Guiana on 25 December 2021; it would unfold later in space. The whole process of setting up the mirror in space, aligning and calibrating it, as well as the cooldown period and commissioning the science instruments, took about six months!

Mercifully for the hundreds of scientists and thousands of engineers involved in the project, everything has gone according to plan thus far. On 24 January 2022, Webb reached its intended orbit around the sun at the second (outer) Lagrange point (L2) – a special spot in the solar system where the telescope can keep a position relative to Earth with a minimum of energy: it continuously faces the night side of Earth, and travels at the same speed as our world. Operating completely in the infrared spectrum, the JWST looks deeper into the past of the universe than any previous telescope was able to do. Its outstanding sensitivity makes it capable of picking up light from the early times of the universe, assumed to be 13.5 billion years ago. Webb can also "look" around in our neighborhood to advance planetary and exoplanet research, for example. So how did Webb come into being, and what was necessary to bring it all the way to where it is now?

FLVT testing at Goddard Space Center with Kistler equipment
Construction of the mirror began in 2004 and was completed in 2011. Scientific instruments were built and installed between 2013 and 2016, and then this hardware was integrated at NASA's Goddard Space Flight Center in Greenbelt, Maryland. This integrated module was called OTIS: it comprises the OTE (Optical Telescope Element) and the ISIM (Integrated Science Instrument Module) and is the functional heart of the entire observatory. Before OTIS was connected to a sunshield and the spacecraft bus, it underwent Force Limited Vibration Testing between November 2016 and February 2017.

Brian Ross, Group Lead Structural Dynamics Test Group at Goddard, was the leading engineer at the time. He recalls: "For the FLVT, we used 28 Kistler force transducers of three different types. They were mounted on a fixture attached to a shaker table." Webb's OTIS structure was vibration-tested in the three

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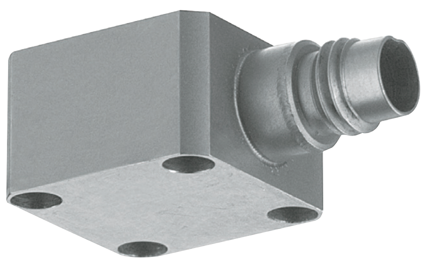
> Sandra Irish, Lead Structures Engineer for the James Webb Space Telescope at Goddard

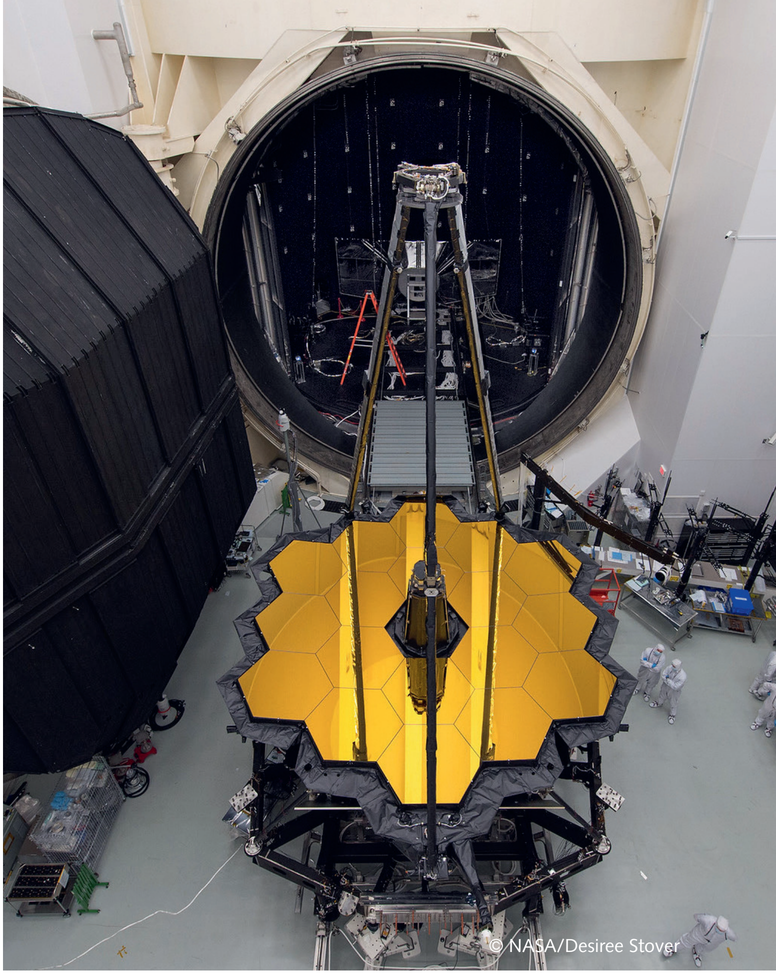
orthogonal axes with a closed-loop control (CLC) system based on precise force measurements. The measuring chain also included charge amplifiers such as the 5080A multichannel lab amplifier from Kistler. Thanks to signal summing and sophisticated calculation, a CLC was successfully established to prevent any overtesting that might jeopardize OTIS, the precious unit under test (UUT). “Although we encountered an anomaly with the first axis early in December, the whole procedure went quite smoothly, and it was only due to the very special nature of the UUT that this happened to be the longest test phase of my career,” Ross adds.

Cryogenic accelerometers help to achieve utmost precision
Webb is an instrument that requires utmost precision: the alignment of the mirror elements, for example, must be absolutely exact. This level of accuracy is achieved by 132 actuators capable of positioning at nanometer level; any unwanted micro-vibrations must also be taken into account. Kistler accelerometers of six different types were used for the various vibration tests (sine vibration, acoustic and shock testing); they include the 8793A500 sensors that are now in space as part of the Webb telescope.



“These triaxial accelerometers have a measuring range of up to 500 g. They were chosen for their ability to operate at very low temperatures down to 25 K,” according to Sandra Irish, Lead Structures Engineer for the James Webb Space Telescope at Goddard. “They worked very well for test-n-fly, but we are also very satisfied with all the other accelerometers we used for test-and-remove. Many of those products were procured and employed only and specifically for the JWST program,” she adds.

Following successful testing at Goddard, OTIS was shipped to NASA’s Johnson Space Center in Houston where the optical testing took place in a giant thermal vacuum chamber during 2017.



NASA’s James Webb Space Telescope sits in front of the door to Chamber A, a giant thermal vacuum chamber located at NASA’s Johnson Space Center. The telescope operates at an extremely cold 39 K (-234° C or -389° F) in space, so NASA simulated those conditions on the ground prior to launch.

By 2019, the OTIS unit was assembled with the sunshield and spacecraft bus at Northrop Grumman’s Space Park, California; the completed JWST then entered the final testing and preparation phase prior to its successful launch in late 2021. Now, scientists and members of the general public are eagerly gaining insights from Webb about our universe – and especially its past history, which was shrouded in darkness until now.

Another L2 infrared telescope already in the pipeline
In the meantime, another great telescope is set to launch soon: the Nancy Grace Roman Space Telescope (“Roman” for short, formerly known as the Wide Field Infrared Survey Telescope) is named for one of NASA’s most famous chief astronomers of the twentieth century. Like Webb, Roman is also an infrared telescope; it has a smaller mirror than Webb, but a very wide view that will focus especially on dark matter and exoplanet research. Its space launch is planned for 2026 – to the same L2 destination as Webb. The major development, construction and testing phases will take place at Goddard Space Center, where all the main components will be built and tested: not only the telescope this time, but also the protective equipment and the spacecraft bus. Brian Ross again: “Procedures are already planned for about two years from now and in the meantime, our facilities will need some upgrading to be capable of testing the whole observatory structure. We’re going to perform three FLVT tests for each part of Roman, and we will certainly rely on Kistler technology again to repeat our success with Webb.”

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