HORIZONS

National Aeronautics and Space Administration

NASA SETMO
SPACE ENVIRONMENTS TESTING MANAGEMENT OFFICE

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NEW AND NOTABLE

Webb Still on Track to Amaze

Despite six micrometeroid dings to the James Webb Telescope mirrors, a panel of experts comprised of representatives from NASA, the European Space Agency and the Canadian Space Agency have concluded in a July report that the damage is, at the moment, inconsequential, and will have little if any effect on current and future observations.

The panel notes that "[Webb] is fully capable of achieving the discoveries for which it was built … to enable fundamental breakthroughs in our understanding of the formation and evolution of galaxies, stars, and planetary systems … [and] we now know with certainty that it will … transform our understanding of the cosmos …"

Nevertheless, the panel concludes that Webb may be more susceptible to damage by micrometeoroids than pre-launch modeling predicted. The project team is conducting additional investigations into the micrometeroid population, how impacts affect beryllium mirrors, and the tradeoffs of pointing restrictions that could minimize the chances of additional harm.

CAPSTONE on the Way

With communications issue resolved, NASA's microwave oven-sized cubesat dubbed CAPSTONE is heading toward an unique orbit intended in the future for Gateway, a lunar space station built by the agency and its commercial and international partners that will support science and human exploration under Artemis. The craft is slated to arrive at its orbital position by mid-November of this year.

Psyche Slips to 2023

The scheduled 2022 launch of the Psyche mission has been delayed. Due to the late delivery of the spacecraft's flight software and testing equipment, there was not enough time to complete essential testing in the remaining launch period, which ends on Oct. 11. When it does fly, the Psyche spacecraft will travel to an asteroid with the same name. It will orbit the asteroid, spending several months mapping and studying its properties.

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FROM THE DIRECTOR

In every life, there are times of major transition. For me, one of those times is now. After 39 years of having the honor of working with and for NASA, I'm now retired as of the end of July. While I find myself looking forward to what will come next, I'm inevitably looking back on where I've been and what I've done. Fortunately, those memories are some of the best I have.

First and foremost, I think of and am grateful for all those with whom I've worked and the friendships I've developed. It may sound like a cliché, but for me, it's the unvarnished truth when I say how appreciative I am for every individual I've had the pleasure of getting to know.

From field centers and testing facilities, to program and project offices, to our small but feisty SETMO headquarters team, people have made my and our work worthwhile. These are smart, energetic, talented colleagues and friends whose enthusiasm, dedication, commitment and creativity are second to none. They exemplify the best and they bring out the best in everything they do.

The Right Choice

When I graduated from Old Dominion University in Norfolk, Virginia with a degree in mechanical engineering, I was faced with a choice: I could continue working at the nearby Newport News Shipyard where I had been an intern for three years, or I could go to work at NASA. The money was better at the Shipyard, but I couldn't escape NASA's appeal. I knew right away I made the right decision.

A source of continued motivation for me, then and now, has been the always challenging and inspirational NASA mission. There are too many of my favorite individual missions to cite here, but among the most outstanding has been the launch, deployment and operation of the Webb space telescope. I can think of no better example of the major role testing has played in mission success than that displayed throughout Webb's extensive and exhaustive development and engineering maturation, from white-board sketch to on-orbit observatory.

We have as this Horizons main feature a glimpse into the Webb-testing process, elaborating on our previous Webb feature in the last newsletter issue. We've already seen the several dramatic observatory images publicly released, and I personally am looking forward with keen interest to the additional pictures and data Webb will reveal over time.

A final article in this issue takes an initial look at what goes into a given facility's repurposing or, in some cases, its demolition, if that better serves testing's overall effectiveness.

Looking Ahead

I'm optimistic about the future and the role NASA does and will continue to play in this nation's space-exploration journey. NASA itself has unparalleled technological expertise and an array of unmatched, robust testing facilities. I have been extremely proud to have been associated with each of them.

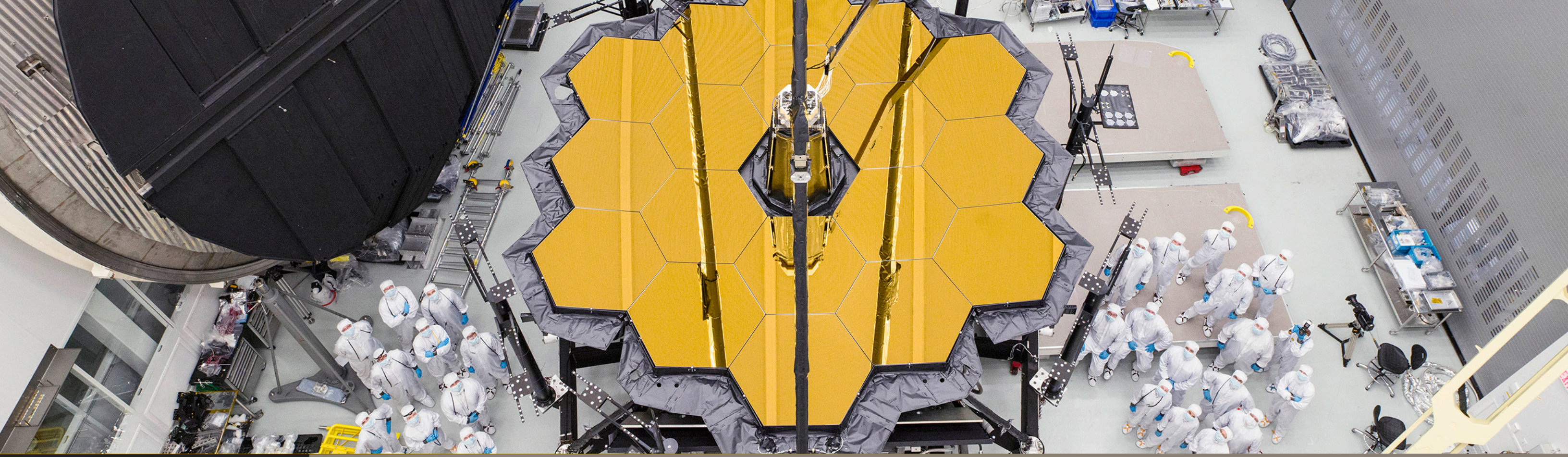
I hope and I believe SETMO will continue to support and sustain these crucial assets, especially necessary as NASA's mission tempo increases. There has never been a greater need for testing, and it will continue to be so just as long as there's an American space program.

I hope you'll continue to visit our website, where we'll continue to add fresh material, including an upcoming video on Artemis testing, as well as new articles and information. And, of course, don't hesitate to reach out to us at hq-setmo@mail.nasa.gov with any comments or feedback.

My tenure is ending just after these first Webb images have been made public. That suits me just fine. I can't imagine a better valedictory.

Many good things are in store, for all of us, I hope. Be well, enjoy, and maybe our paths will cross again. My best to you and yours in all the time still ahead —

Michael Mastaler



STRESS TESTS Making a Hardy Webb

Verifying the ability of a next-generation orbital telescope to survive and thrive in space.

As the world marvels over the first public images from the James Webb Space Telescope, Webb Deputy Project Manager for Technical Verification Paul Geithner is able to recall another first-of-its-kind moment: when the Webb team thought for a brief — blessedly brief — moment it had actually broken part of the observatory.

A portion of the Webb structure, custom-made of graphite epoxy composite, underwent vibration testing at NASA's Goddard Space Flight Center in late 2016. Connection points in the instrument's deployable components were stressed to see how they would hold up. All was going well, until it wasn't. There was a loud crack. The sound wasn't pretty.

"People said 'Oh my god, did we just break it?" Geithner remembers. "I mean, it sounded bad. Then the test automatically shut down. That was probably the scariest point."

No harm was done. Tuned mass dampers were added to the telescope's secondary mirror support structure to suppress any resonances that would threaten the structure's survival during launch. Testing then, and in the months and several years to come, continued as the mission team assessed the observatory's hardiness for the extreme conditions it would encounter, both during launch and in its eventual permanent Lagrange Point 2 (L2) "halo" orbit — larger than the size of the Moon's orbit around Earth — gravitationally balanced between Earth and the Sun.

Webb's destination orbit is thanks to Italian-born 18th century mathematician and astronomer Joseph-Louis Lagrange, who made important contributions to classical and celestial mechanics. Lagrange studied the "three-body problem" (thus named because of three bodies that orbit one another) for the Earth, Sun and Moon. He identified five points in near space — L1 through L5 — where objects could be easily orbited.

The Webb observatory — the most complex and powerful space telescope launched to date — is an exemplar of how testing next-generation, space-borne designs and gear in environments that closely mimic those found in a hard, ultracold and/or ultrahot, radiation-laced vacuum can protect as much as possible against known dangers and, perhaps, even unknown ones.

Webb's problem-free launch, orbital insertion and, to date, successful deployment and systems checks underscores testing's worth. Such progress would not have been possible without extensive study and validation of all Webb systems and components prior to the telescope's launch and deployment. But a major question was how, exactly, could tests be conducted for such a large apparatus?

Splitting Up the Right Thing to Do

Even testing in the largest of NASA's vacuum chambers wasn't feasible, given the need to precisely replicate the thermal environment on both sides of the observatory in its deployed configuration. A possible approach was to build another very large chamber to do so, but construction costs and the resultant schedule delays were prohibitive.

The solution: literally split the observatory into a pair of large halves that could be accommodated — admittedly, with some facility adjustments and upgrades — in a variety of test chambers spread across NASA centers and prime contractor Northup Grumman's Redondo Beach, Calif. facilities. Verification of deployments and Webb's thermal balance occurred as the result of combinations of many tests.

Webb structures, components, electronics, instruments, and systems would be studied, evaluated and validated by, eventually, thousands of scientists, engineers, and technicians who in aggregate would build, test, and integrate Webb. In total, 258 companies, agencies, and universities participated — 142 from the United States, 104 from 12 European nations, and 12 from Canada.

"We couldn't just stick the entire observatory in one vacuum chamber and duplicate everything at the same time," Geithner says. "So that's why we tested in two big halves. It turned out our approach worked."

NASA facilities involved in major Webb testing were ones located at NASA research centers: Goddard Space Flight Center; Johnson Space Center; Marshall Space Flight Center; and the Jet Propulsion Laboratory. Cryogenic — ultracold — testing of the telescope, its components and instrument packages figured prominently in those efforts, as well as vibration and thermal-balance assessments.

"We had to figure out how to test in two parts and trust software would certify the results of that testing," says Webb

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NEW AND NOTABLE

VIPER Rescheduled for 2024

Volatiles Investigating Polar Exploration Rover, or VIPER, is now scheduled for launch no earlier than November 2024 to allow for additional ground testing of its lunar-lander system. VIPER is a mobile robot that will go to the South Pole of the Moon to get a close-up view of the location and concentration of water ice that could eventually be harvested to sustain extended human exploration on the Moon, Mars and beyond. VIPER represents the first resource-mapping mission on another celestial body.

Program Scientist Eric Smith, now chief scientist in the Astrophysics Division at NASA Headquarters. "That was so when we put the parts together the observatory would work in space. Lo and behold — it worked amazingly."

Clean but Stormy

Beginning in July 2017 at Johnson Space Center, in its Chamber A facility, scientists and engineers put Webb's optical telescope and its integrated science instrument module known as OTIS through a series of cold-stress tests as well. Those studies included an important alignment check of Webb's 18 primary mirror segments, to ensure all the observatory's gold-plated, hexagonal segments acted like a single, monolithic mirror.

This was the first time the telescope's optics and its instruments were tested together, though the instruments had previously undergone cryogenic testing in a smaller chamber at Goddard. Engineers from Harris Space and Intelligence Systems, headquartered in Melbourne, Florida, worked alongside NASA personnel for the test at Johnson.

Before Webb was placed inside, Johnson engineers built a large cleanroom around the Chamber A entrance. The modification, Smith says, "turned a 'dirty' chamber into a clean one. That was a big investment." The cleanroom enabled the telescope to be hoisted from its shipping container and unwrapped from protective bagging, deployed, rotated from horizontal to vertical, placed on its test platform and, finally, slid into the chamber on rails and hung from the six long suspending rods.

"Chamber A was a pretty obvious choice, aside from building an entirely new facility," Geithner says. "It was a lot better than starting from scratch. It's a really nice facility where you can pull a really high vacuum."

While Webb was inside the chamber, insulated from both outside visible and infrared light, engineers monitored it using thermal sensors and specialized camera systems. The thermal sensors kept tabs on the temperature of the telescope, while the camera systems tracked the physical position of Webb to see how its components moved during the cooldown process.

Not all would go to plan. Although savvy testers learn to expect the unexpected, some events will try the patience of even the best-prepared.

"Our testing plan was solid. We prepped a lot at JSC," Geithner says. "We planned for and upgraded so we would survive a 500-year hurricane. And guess what happened? Hurricane Harvey."

Harvey slammed into the coast of Texas on August 25, 2017, as a Category 4 hurricane before stalling over eastern Texas and weakening to a tropical storm, where it dropped as much as 50 inches of rain in and around Houston. Despite the maelstrom, Webb telescope team members at Johnson remained in place for uninterrupted, three-shifts work for 100 days straight.

Another problem arose: liquid-nitrogen supplies, essential to maintaining the ultra-cold conditions in the chamber, were running low. The test's technical leader, telescope manager Lee Feinberg, made an emergency call to the nitrogen supplier, explaining the nature and urgency of the mission. Drivers from Austin rushed to deliver and replenish the liquid nitrogen, arriving just in the nick of time.

"People went the extra mile to keep the test going and the hardware safe," Geithner says. "All of us were determined. We were committed."

Understanding Testing

They didn't pack the punch of a hurricane, but two other incidents gave testers some pause. Acoustic testing in 2017-18 by Northrop Grumman resulted in a number of #4 locking bolts in the Webb sunshield falling off. Although it was, Geithner recalls, "a colossal annoyance" as engineers worked to solve the problem. it proved not to be a game-ender. As he points out, "That's why you test, right?"

Closer to launch, in December 2021 as the Webb payload was being encapsulated, a launch interface ring sprung open and, Eric Smith says, "flew away. Happily, there was no effect. Still, it was pretty scary to see a piece of the rocket detach like that."

Smith still remembers his visits to NASA's Space Environments Complex at what is now the Armstrong Test Facility, part of Glenn Research Center. There he was able to see testing's inner workings, including the variety and extent of the complex equipment required to assess and verify the hardiness of spacecraft, structures, systems, components and instruments.

Smith says mission team members, even those not directly engaged with testing, should become familiar at some level with testing regimes, procedures and processes — not to mention the people who actually and actively oversee what goes on in the chambers.

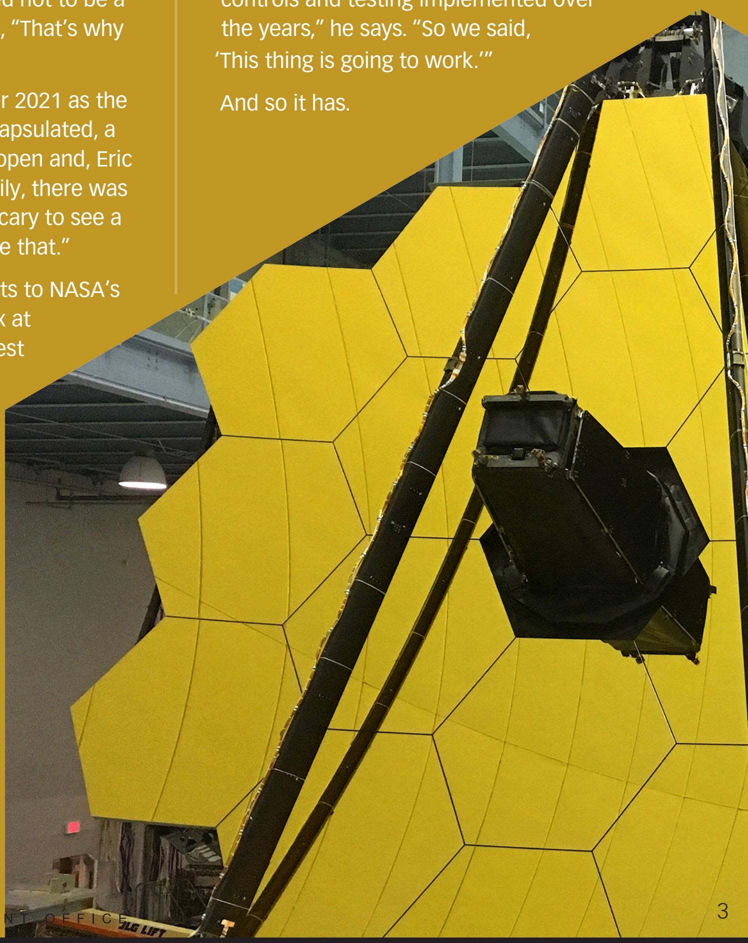
"As a scientist you should want to get to know your engineers. Get to know them so you understand their language so you understand the testing program," he asserts. "That's what scientists need to think more about. Go into a program or project with testing in mind, from the very beginning."

Identifying problems, reducing risk, increasing mission safety and effectiveness — these are the guiding principles for testing. They may not fit comfortably as words on a bumper sticker, but for all missions, past, present and future, they're the ones that testers live and work by.

Webb completed all its deployments in the first two weeks after launch, while it was traveling toward L2. It did not insert into its destination orbit until a month after launch. By then, Geithner and his Webb colleagues knew that the observatory had passed successfully beyond every of the potential 295 single-point deployment failures the team had identified and prepared for.

"All of those failures could have happened, and they didn't, thanks to all the process controls and testing implemented over the years," he says. "So we said, 'This thing is going to work.'"

And so it has.



Absent refurbishment and/or repurposing, older testing facilities face demolition.

There are those truly fond of "Big Iron": typically, large research enclosures where scale models are studied and assessed in a wide variety of atmospheres and temperatures. Such structures, though, can't always survive the march of technology when surpassed by the increasing power and sophistication of computer simulation, and the parallel creation of next-generation sensors and the complex physical systems they comprise.

When upgrading isn't realistic economically or technologically, then the time has come to make another choice. Nostalgia must inevitably give way to reality.

"We need to be open and honest. We sustain where we can, where it makes sense, and where a good case can be made for the return on investment," says SETMO Director Michael Mastaler. "But demolition has to be part of the discussion. Talk about divestiture or demolition, and you will get pushback. But it can be the best decision you can make."

Straightforward Questions, Complex Answers

NASA's history is replete with examples of capabilities and facilities that go through a more or less predictable life cycle: brand new, sustained while needed and, eventually, demolished when outmoded and outdated. Mastaler says keeping a facility going strong boils down to the best-use case. Personnel, maintenance and operations costs, and frequency of use are key considerations and must be continually factored in. It doesn't do any good to have the best test facility with little or no interest from testing programs, or with test costs so high that they deter potential customers.

Other Considerations

- Is it worth it to have Agency research capabilities on standby just in case?
- Which facilities are essential in avoiding genuine catastrophe for users like NASA, the U.S. Department of Defense, and commercial and international interests?
- Which facilities can perform multiple test roles?
- Which facilities uniquely provide other critical information?
- When there are other options, which facilities provide the best value to the testing customer when considering time, proximity, existing databases, and cost?

Answers to these questions usually aren't simple ones to make. Conclusions — and solutions —take time. And other complicating factors can intervene unexpectedly as well.

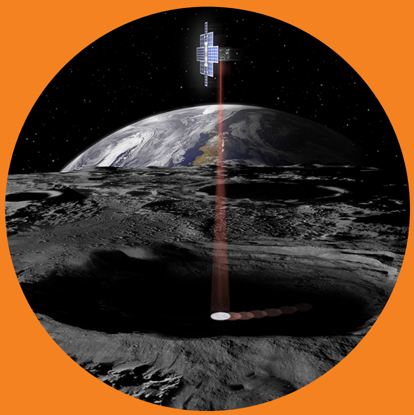
Positive and Flexible

Recently, the decision was made to demolish NASA Langley's Thermal Acoustic Fatigue Apparatus (TAFA). Built in 1965, the facility was last modernized in 2009. Its current replacement value is estimated in the millions: an economic reality that argues against its retention and upgrade. TAFA teardown, Mastaler says, will free up more space for Langley acoustics researchers: "In this case, it makes sense. It's a positive step."

At another NASA center, Marshall Space Flight Center, planning is underway for the repurposing of its Chamber V-20, from a "clean" to a "dirty" vacuum chamber. As NASA prepares for extended missions to the Moon and Mars, there need to be facilities where surface materials on both can be simulated so that effects on astronauts, their gear, their rovers, and whatever habitats they deploy can be closely studied and assessed.

Very unlike Earth soil, lunar and Martian "soil" don't contain the organic substances found on Earth. For example, on the Moon, tiny grains of rock-like material called regolith coat the surface, while Martian sand and dust predominate on that planet.

"The V-20 chamber is a good and recent example of repurposing," Mastaler says. "The idea of repurposing is so that an asset is used in a different way. At the end of the day, the motto is 'be flexible.' The Marshall chamber is a real-world example."



ISRU Technology Program Review

As explorers fan out through the solar system, a primary requirement is to find practical and affordable ways to use resources along the way. Using local materials to, for example, generate water for drinking, hygiene, and plant growth; create rocket propellants; fashion building materials; and satisfy a myriad of other needs, is a practice known as in-situ resource utilization, or ISRU. In mid-August, SETMO participated in the second annual NASA ISRU Technology Program Review, which focused on funded active or recently completed ISRU efforts.

The review was a hybrid event, with a physical location near NASA's Johnson Space Center in Houston, Texas, as well as virtual presentations and interactions for participants who did not travel. The information presented informed NASA and partner Johns Hopkins University Applied Physics Laboratory on the state of ongoing efforts in NASA-funded ISRU technology development, and helped identify areas where further funding and development is required in future NASA solicitations.

Launch of the Artemis I Uncrewed Mission

Scheduled for its maiden flight on August 29, the uncrewed Artemis I mission was scrubbed because of a temperature issue with one of its Space Launch System (SLS) rocket's four engines. Although two early-September launch windows remained open at that time, no additional flight dates were specified by NASA officials immediately after the postponement.

Engineers were unable to coax the engine in question to the proper temperature range required for ignition, and ran out of time in the two-hour launch window to continue. All four of the SLS RS-25 engines must be thermally conditioned before super-cold propellant begins flowing and liftoff commences.

An earlier issue with a component called a "collet" — a fist-sized ring that guides the quick disconnect during assembly operations, where a liquid hydrogen umbilical attaches — has been resolved. During work to repair the source of a hydrogen leak, engineers identified a loose fitting on the inside wall of the rocket's engine section and made the necessary adjustments.

A crewed Artemis Moon landing could come as early as 2025, with additional Artemis missions to follow. Eventually, astronauts may extend their stay on an Artemis base camp that may include a lunar cabin, a rover, and even a mobile home. As the base camp evolves, crew may remain on the lunar surface for up to two months at a time.

X-59 Testing to Prep for the First Test Flight

The X-59 QueSST — short for Quiet Experimental Supersonic Technology — aircraft is schedule to begin its first overland test flights at the end of the year. To provide regulators with data for changing aviation rules that ban commercial supersonic flight over land, NASA plans to fly the X-59 over a number of U.S. communities and survey populations on the acceptability of the sound they hear. NASA will share this information with national and international regulators.

Lockheed Martin's Skunk Works facility in Palmdale, California, has completed low-speed wind tunnel tests of a scale model of the X-59's forebody. The tests provided measurements of how wind flows around the aircraft nose and confirmed computer predictions made using computational fluid dynamics software tools. The data will be fed into the aircraft flight control system and will allow the pilot to know the X-59's altitude, speed, and flight angle.

Engineers placed small wind vanes on the X-59 model to measure the angle of the wind at the precise location of the air data instruments on the full-scale aircraft. The testing compared the data collected from the wind tunnel with computer model predictions and confirmed agreement.

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