National Aeronautics and Space Administration

THE ARMSTRONG X-PRESS

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# X-59

## NASA marks progress on newest X-plane

Lockheed Martin Illustration

*NASA's X-59 Quiet SuperSonic Technology X-plane, or QueSST, is designed to fly faster than the speed of sound, without producing a loud, disruptive sonic boom, which is typically heard on the ground below aircraft flying at such speeds. Instead, with the X-59, people on the ground will hear nothing more than a quiet sonic thump – if they hear anything at all. The X-59 will fly over communities around the United States to demonstrate this technology, providing scientifically valid data from the community overflights. The data will be provided to U.S. and international regulators who will use the information to help them come up with rules based on noise levels that may enable new commercial markets for supersonic flight over land.* *See related articles on pages 4-6.*

# FO demonstrates landing technology

**Nicole Quenelle**
Fuentek

A navigation doppler lidar (NDL) technology originally developed by NASA was demonstrated on a flight test on Sept. 10 with support from the Flight Opportunities program, part of NASA's Space Technology Mission Directorate. With roots at NASA's Langley Research Center in Hampton, Virginia, the technology was licensed in 2016 by Psionic for terrestrial and space applications and the company and Langley continue to evolve and advance the innovation for upcoming lunar missions.

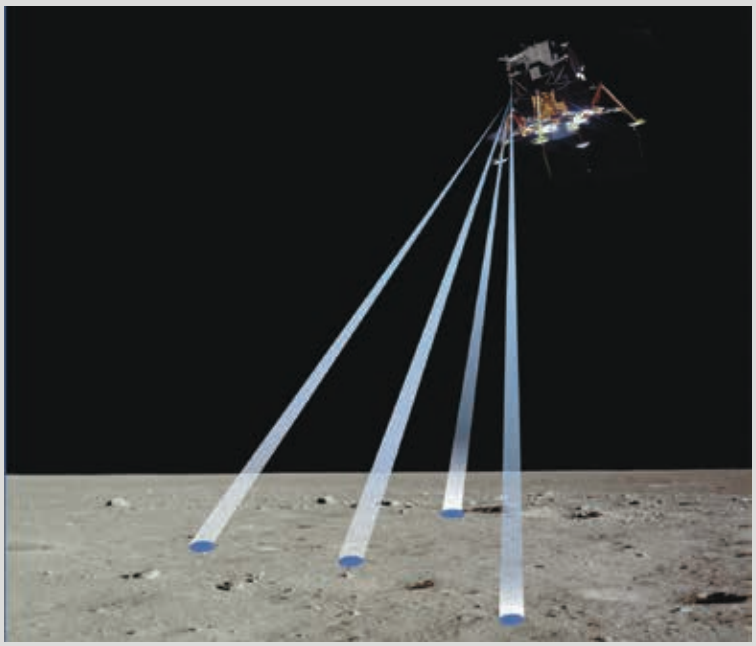
On the recent flight in Mojave, California, Masten Space Systems flew Psionic's NDL payload on a vertical takeoff vertical landing (VTVL) system called Xodiac, which simulates some of the maneuvers of a lunar lander. Designed for precision landing in a very tightly defined area – often called the landing ellipse – the NDL transmits laser beams to the ground that bounce back to a sensor, providing information about the lander's velocity and distance relative to the ground.

The flight test was designed to help Psionic validate their NDL unit's algorithms and data processing in order to verify the accuracy of these measurements. Data analysis is now underway to determine any modifications needed before advancing to a future closed-loop flight test on Xodiac, in which Masten and Psionic will use the NDL payload to actually navigate the VTVL system.

Psionic is also continuing research and development on variations of the NDL technology – such as using an additional laser beam and other new components – in parallel with Langley's efforts to advance elements of the technology.

**AFRC2020-0100-30** **NASA/Lauren Hughes**

*The NDL payload flight tested technology to enable precision landing on the Moon.*



**Psionic**

*Laser beams transmit velocity and distance information from the lunar surface.*

"The Flight Opportunities program enables us to move from modeling and prototypes to relevant flight conditions to confirm that the improvements perform the way we expect," said Steve Sandford, founder and chief technology officer of Psionic, based in Hampton, Virginia.

Flight Opportunities was also instrumental in earlier testing of the technology on flights in 2017 as part of NASA's COBALT project, or Cooperative Blending of Autonomous Landing Technologies.

"Those flights, along with a 10-year period of technology development at Langley, have been instrumental in making the NDL technology available to commercial lunar landers for future NASA missions," said Farzin Amzajerdian, principal investigator for the NDL technology at Langley.

Psionic's technology transfer relationship with NASA is helping to facilitate that goal by enabling the company to produce flight-ready NDL units that could be used by companies on contract under NASA's Human Landing System (HLS) Program.

Amzajerdian explained that Langley is continuing flight testing of NDL units as well, adding to the wealth of data available between the agency and its commercial partners to help

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# SOFIA resumes flights

**By Felicia Chou**
NASA Headquarters Public Affairs
and **Alison Hawkes**
NASA Ames Public Affairs

NASA's flying observatory, the Stratospheric Observatory for Infrared Astronomy, has returned to science operations with a new series of flights designed to study the chemistry of galaxies.

SOFIA flights were suspended on March 19 in response to the COVID-19 pandemic. With the resumption of flights out of SOFIA's base at NASA Armstrong, new procedures are in place to ensure the health and safety of staff while enabling the observations of celestial targets visible from the Northern Hemisphere. SOFIA started by flying two flights beginning Aug. 17, to allow the team time to evaluate and adjust the new procedures, and now plans to return to its regular observing schedule with about four flights each week.

ED07-0237-08 NASA

*NASA's Stratospheric Observatory for Infrared Astronomy is returning to science operations.*

"We are so thrilled to begin observations again and very thankful to the scientists, operations staff and pilots who are returning us to flight," said Margaret Meixner, SOFIA's science mission operations director at the Universities Space Research Association. "In this flight series, SOFIA is studying the chemistry that influences the creation and evolution of

**SOFIA, page 7**

# Ruth proves dreams can happen

**By Leslie Williams**
NASA Armstrong News Chief

Female pilots are still rare in the aviation industry and that's also true at NASA.

At NASA Armstrong former U.S. Air Force pilot Elizabeth "Liz" Ruth flies NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA). The aircraft is a modified Boeing 747SP with the world's largest airborne astronomical observatory.

Research pilots are a blend of courage, boldness and a curiosity to push boundaries in the pursuit of knowledge. By flying SOFIA, Ruth represents for many women that they can follow their dreams, like the uniqueness of flying a 747 that studies the universe.

**Ruth, page 7**


AFRC2020-0100-30 NASA/Lauren Hughes

*Research pilot Elizabeth Ruth is the only female pilot who flies the Stratospheric Observatory for Infrared Astronomy (SOFIA). Ruth has been flying SOFIA for NASA Armstrong since 2016.*

# News at NASA

## Bus size asteroid passes by

**Ian J. O'Neill**
JPL Public Affairs

A small near-Earth asteroid (or NEA) will briefly visited Earth's neighborhood Sept. 24, zooming past at a distance of about 13,000 miles (22,000 kilometers) above our planet's surface. The asteroid made its closest approach below the ring of geostationary satellites orbiting about 22,000 miles (36,000 kilometers) away from Earth.

Based on its brightness, scientists estimate that 2020 SW is roughly 15 to 30 feet (5 to 10 meters) wide – or about the size of a small school bus. Although it's not on an impact trajectory with Earth, if it were, the space rock would almost certainly break up high in the atmosphere, becoming a bright meteor known as a fireball.

"There are a large number of tiny asteroids like this one, and several of them approach our planet as close as this several times every year," said Paul Chodas, director of the Center for Near-Earth Object Studies (CNEOS) at NASA's Jet Propulsion Laboratory in Southern California. "In fact, asteroids of this size impact our atmosphere at an average rate of about once every year or two."

After asteroid 2020 SW was discovered on Sept. 18 by the NASA-funded Catalina Sky Survey in Arizona, follow-up observations confirmed its orbital trajectory to a high precision,

**Asteroid, page 8**

# X-59 assembly ongoing

**Matt Kamlet**
NASA Armstrong Public Affairs

Assembly of NASA's X-59 Quiet SuperSonic Technology aircraft is continuing during 2020 and making good progress, despite challenges such as those imposed by the unexpected global pandemic.

NASA plans as early as 2024 to fly the X-59 over select communities on missions to gather information about how the public will react to the level of quiet supersonic flight noise the aircraft is designed to produce – if they hear anything at all.

Data collected will be shared with federal and international regulators to help them set new rules that may allow supersonic flight over land and enable a whole new market for commercial faster-than-sound air travel.

"This mission is the culmination of decades of research, and with the X-59 we are continuing to pioneer a future of aviation in which we will see drastically reduced flight times for global-travelling passengers," said Peter Coen, NASA's Low-Boom Flight Demonstration Mission integration manager.

**Lockheed Martin**

*NASA's X-59 Quiet SuperSonic Technology X-plane, or QueSST, will demonstrate quiet supersonic flight over communities in the United States.*

For now, assembly of X-59 is taking place at Lockheed Martin's Skunk Works facility in Palmdale, where with each construction milestone, the airplane is taking shape – literally.

One of those milestones is with the X-59's eXternal Vision System, or XVS, which is a forward-facing camera and display system that allows the pilot to see outside the aircraft via augmented reality.

The XVS is NASA's solution to the aircraft's lack of a forward-facing window – a result of the need to place the cockpit lower and farther back on the airplane because of its unique, elongated nose and fuselage profile.

The innovative XVS system underwent successful flight tests in August 2019 and passed several rounds of qualification testing in January of this year.

Major progress was also made on the aircraft's wing thanks to the Skunk Works' Combined Operation: Bolting and Robotic Auto-drill (COBRA) system. This advanced robotic technology enhances production by drilling and inspecting hundreds of holes on the wing that are part of the assembly process.

Meanwhile, pallet brackets were recently installed into the airframe for the XVS and flight test instrumentation systems, marking the first installation of components supplied directly by NASA for the X-59.

**Assembly page 5**

# Specialty engine for X-59 arrives at NASA Armstrong

**Jim Banke**
Aeronautics Research Mission Directorate

Mark the big one-of-a-kind engine, designed and built just for NASA, as delivered.

Nearly 13 feet long, three feet in diameter, and packing 22,000 pounds of afterburner enhanced jet propulsion, the F414-GE-100 engine is now at NASA Armstrong.

There it will be checked out and inspected before it is transported to nearby Palmdale for eventual installation into NASA's X-59 Quiet Supersonic Technology airplane, which is now under construction at Lockheed Martin's Skunk Works factory.

"Taking delivery of the engine from General Electric marks another exciting, huge milestone for us in building the X-59," said Raymond Castner, the propulsion lead for the X-59 at NASA's Glenn Research Center in Cleveland.

In fact, two engines were delivered. One to serve as the primary engine and the other to be used as a backup when needed.

"This just adds even more anticipation as we look forward to seeing

**Engine page 6**


**GE Aviation**

*The F414-GE-100 engine from the assembly area at GE Aviation's Riverworks facility in Lynn, Massachusetts, will power NASA's X-59.*

# Assembly... from page 4

Moreover, the X-59 has achieved several other milestones, including delivery of several major aircraft segments that will soon be installed. These include the F414-GE-100 turbofan engine from General Electric Aviation, the aircraft's vertical tail, and the one-of-a-kind, extended-length nose.

Although production and assembly have continued at a steady pace in many areas the development of an all new, full scale experimental aircraft is not without its challenges.

As a result, some schedule updates have been implemented.

NASA now expects the X-59's assembly to be complete and major ground testing to begin in summer 2021, leading to a target date for first flight in summer 2022.

"The integrated NASA and Lockheed X-59 team is doing an amazing job given the challenging circumstances of COVID-19," said NASA's LBFD Project Manager Craig Nickol. "The team has shown remarkable resilience, and we're excited to see the visible progress on X-59 assembly and integration every day. Although we have had some challenges in 2020, the team has responded well by updating plans and continuing to make progress. We're looking forward to several important milestones this year."

These milestones include completion of manufacturing the X-59's wing and its mating to the aircraft's fuselage, both expected by the end of 2020.

"We are over half-way complete with the build of this one-of-a-kind X-plane," said David Richardson, X-59 program director, Lockheed Martin Skunk Works. "We will soon complete close-out of the wing, which is the central structural anchor of the aircraft, and we will then prepare for mate of the empennage, fuselage, and the distinctive, super long nose. The team has done a phenomenal job of advancing aerospace technology and working through challenges to drive progress, all of which has been enabled by our close partnership with NASA."

Lockheed Martin

*The unique, elongated nose for NASA's X-59 Quiet SuperSonic Technology, or QueSST, aircraft is a critical element in NASA's design to reduce the loud sonic boom, heard from supersonic aircraft, to no more than a quiet thump. Seen here at Lockheed Martin's Skunk Works facility in Palmdale, the nose for the X-59 is over 30 feet long – long enough for pilots to require an innovative virtual system to see beyond the front of the aircraft.*

None of the schedule adjustments threaten timing of the ultimate goal of delivering results of the community overflights to the International Civil Aviation Organization and Federal Aviation Administration in 2027.

With that information in hand, regulators will be able to decide if a change should be made in rules that prohibit supersonic flight over land – a decision that would be expected in 2028.

Before then, however, and even as the X-59 aircraft is under construction, other teams of NASA's aeronautical innovators are preparing for their roles in what NASA calls the Low-Boom Flight Demonstration mission.

Once the X-59 begins flying, it will be important to validate that it is capable of producing supersonic shockwaves that will lead to quiet thumps in place of loud sonic booms. This will require tools for shock wave visualization, in-flight pressure measurement, and acoustic validation – technologies which are continuing preparation and testing at NASA, on the ground and in the air.

These acoustic validation flights are targeted for 2023.

At the same time, critical planning and preparation for the community overflights continues – flights that are expected to begin in late 2024. The effort is taking advantage of lessons learned from a flight series that took place over Galveston, Texas in 2018.

Taken together, this mission work is spread across three projects within NASA's Aeronautics Research Mission Directorate. They include the Commercial Supersonic Technology project managed out of NASA's Langley Research Center in Virginia, the Flight Demonstrations and Capabilities project managed out of NASA Armstrong, and the Low Boom Flight Demonstrator project, responsible for the X-59 aircraft itself, managed out of Mary W. Jackson NASA Headquarters in Washington, DC.

X-59's mission to provide regulators with data that may open the future to supersonic flight over land, drastically reducing flight times, is the culmination of decades of NASA supersonic research. While the challenge is there, NASA, as it always has, is pioneering the future of flight through the first "A" in its name – Aeronautics.

# Engine... from page 4

that big flame come out the back of the aircraft as it takes off for the first time," Castner said.

Assembled and initially tested at GE Aviation's Riverworks facility in Lynn, Massachusetts, the engine will power the X-59 on missions to gather information about how the public will react to the quieter sonic booms the aircraft is designed to produce – if they hear anything at all.

Data collected will be shared with federal and international regulators to help them set new rules that may allow supersonic flight over land and enable a whole new market for commercial faster-than-sound air travel.

"It's important to note that neither the X-59, nor this particular engine, are prototypes for a future commercial supersonic airliner," Castner said. "This hardware is just for proving the airplane can produce quiet sonic thumps and measure community response."

**Procuring the power**

As preliminary designs for the X-59 were put together several years ago, the initial plan was to power the aircraft with the same jet engines used by NASA's F/A-18 research jets based at Armstrong.

"We had an inventory of spare engines and parts and thought we could use the engines we already owned, but that didn't pan out," Castner said.

The problem was the engine – GE's model F404 – couldn't generate enough thrust to achieve the flight performance goals for the X-59. As designed, it took two of the engines to power the F/A-18, but the X-59 only had room for a single engine.

Working with GE, the solution was found in adapting the F404's next-generation improvement, the F414 engine, into a configuration that would both satisfy the X-59's power needs and physical size.

Anthony Hazlett, GE's X-59 demo model engineer at the Lynn facility, was responsible for leading the group that came up with the unique engine design for the experimental supersonic airplane.

"We had developed a single-engine version of the F414 for Sweden's Saab JAS 39E Gripen fighter that we determined would work for the X-59 with some modifications, so we derived a new engine model, the F414-GE-100," Hazlett said.

"The tried and true guts of the engine, all the turbomachinery, are the same or very similar. But the engine's external design and the way the engine operates was upgraded."

That included something as complicated as writing new control systems software so the engine and X-59 could talk to each other, and something as relatively simple as adding plumbing in new places so fuel could flow from the airplane to the engine.

**Some assembly required**

Although not considered a big deal, another difference between the X-59 engine and the Gripen jet engine it was originated from is the installation method. But that doesn't mean the process will be any easier.

"There is still a significant chunk of effort that lays in taking something that's well known and installing it into a new aircraft," Hazlett said. "So, we'll have a team from GE present to help Lockheed Martin with the process."

What's the difference?

Versions of both the F404 and F414 engines have included track hardware to assist in installing the powerplant. Either the engine is put on a cart and placed at the back of the aircraft to roll it right in, or it's placed underneath the airplane and a lift is used to raise the engine into place – in both cases using the track hardware as a guide.

But to save weight and space, the X-59's version of the F414 does not have the tracks, so the engine – which will be placed underneath the aircraft and lifted – will rely on human eyeballs and hands to manually guide it into place.

Once mechanically bolted in place, electrical, fuel, and various other lines will be hooked up and the whole engine/aircraft combination system tested. That will lead to the first time the engine is fired up within the aircraft as it remains in place with brakes on and restraining tethers fastened.

"This whole process will take several months to perform as various tests are scheduled within certain windows that are available to us as assembly on the airplane continues," Castner said.

**Factory fresh**

Although the engine is based on the design of the Gripen's engine – known as the F414-GE-39E – GE did not just take a 39E engine in stock and modify it for NASA to use on the X-59.

"This is a whole brand-new engine birthed from raw metal," Hazlett said. "The NASA team is getting a new engine straight from the dealership floor."

As part of that manufacturing process, the engine already has undergone more than eight hours of successful operations on a test stand in Massachusetts to prove it would be capable of supporting the way the X-59 is expected to fly.

A typical fighter mission will see the pilot move the engine throttle a number of times, with short bursts of high power between periods of average thrust. This affects the engine's overall durability and design lifetime of its parts in a way that is fully understood.

"With the X-59 we looked at how it will be flying, which is different from a fighter. It will have longer duration missions at high altitude with high power – often with the afterburner firing to reach supersonic speeds," Hazlett said.

Putting the X-59's engine through its paces at a GE test cell in Lynn showed it could handle the high afterburner usage and demonstrated all other design upgrades, such as the newly designed control software, would work as expected.

"It's been a great challenge for our design team to prove our assumptions and boundary conditions are still good, and we've met that challenge in every way," Hazlett said.

With plenty of work to do on other programs, many in support of the U.S. military – and notwithstanding the additional challenges imposed by the COVID-19 pandemic – GE had no problem keeping an appropriate focus on the NASA work to achieve that goal.

The opportunity to work on a NASA X-plane – the first of its kind in three decades – was a big reason.

"X-59 has a mission unparalleled in terms of its cool factor. There's been no shortage of folks who want to help and work on this program. It's something that GE is extremely proud to be a part of," Hazlett said.

From NASA's perspective, Castner concurs.

"Working with GE to make this engine available has been fantastic. They have been an invaluable partner in all of this. We are very fortunate to have them as part of the team."

## Technology... from page 2

advance lunar navigation and precision landing. NASA's NDL units will fly to the Moon on two early flights under NASA's Commercial Lunar Payload Services initiative.

Lander providers are also contributing to landing and navigation expertise. For instance, Masten is applying lessons learned from its history of testing navigation technologies to prepare for their own lander under development to deliver CLPS payloads for NASA to the Moon's South Pole.

"With these flights, we're providing the testing service, but also we get exposed to the technology through so many steps and refinements along the way," said Reuben Garcia, director of technical operations at Masten. "Now we can implement the learning from all these previous tests and see the results firsthand. That buys down the technical risk for us, for Psionic, and for NASA whose missions will benefit from this work."

By bringing together multiple experts from different sectors, the Flight Opportunities program is helping NASA advance the future of commercial spaceflight, according to John Kelly, program manager for Flight Opportunities. NASA Armstrong manages the Flight Opportunities program for the agency.

"It's gratifying to see a NASA center, a small business, and a commercial flight provider collaborating together to advance technology solutions for one of NASA's most ambitious goals – landing on the Moon."


**AFRC2020-0100-22** **NASA/Lauren Hughes**

*Masten employees prepare for a rocket flight test of lunar landing technology.*

## SOFIA... from page 3

galaxies across cosmic history. We cannot wait to see the data."

The team will explore distant galaxies to learn how black holes control the galaxies' growth and how quickly stars form in them. To further understand star birth, the team will examine how magnetic fields affect the celestial clouds that incubate natal stars.

In June, SOFIA's annual deployment to Christchurch, New Zealand was deemed not feasible given ongoing concerns related to the pandemic. Instead a new schedule was coordinated to take advantage of observing opportunities from California. New safety procedures are designed to meet NASA and Federal Aviation Administration requirements for safety and return to on-site work. New procedures include flying a minimal number of mission crew, social distancing and personal protective equipment for staff, and extra sanitation of the aircraft during and in-between flights.

SOFIA is a Boeing 747SP jetliner modified to carry a 106-inch diameter telescope. It is a joint project of NASA and the German Aerospace Center, DLR. NASA's Ames Research Center in California's Silicon Valley manages the SOFIA program, science and mission operations in cooperation with the Universities Space Research Association headquartered in Columbia, Maryland, and the German SOFIA Institute (DSI) at the University of Stuttgart. The aircraft is maintained and operated from NASA Armstrong's Building 703 in Palmdale.

**NASA/SOFIA; NASA/JPL-Caltech**

*Composite image shows the Cigar Galaxy (also called M82), a starburst galaxy about 12 million light-years away, in the constellation Ursa Major.*

## Ruth... from page 3

"I always wanted to be a pilot because flying meant adventure and service to my country," Ruth said. "Even though pilots were mostly men, I knew I would go through the same world-class training and have to meet the same standards of excellence as every other pilot. Once you earn your wings, everyone is equal in the sky."

Before joining NASA as a research pilot, she was a pilot for United Airlines. It was in the Air Force, however, where Ruth gained the knowledge and background to advance. She was an instructor pilot, check pilot and aircraft commander for the T-38 and T-43 from 1981 to1989. She concluded her military career with the rank of captain.

"Don't let anyone tell you no and be willing to do what it takes to be a pilot," Ruth said. "Though it's fun, it takes a lot of determination and dedication."

## Asteroid... from page 3

ruling out any chance of impact. After the Sept. 24 close approach, the asteroid continued its journey around the Sun, not returning to Earth's vicinity until 2041, when it will make a more distant flyby.

In 2005, Congress assigned NASA the goal of finding 90% of the near-Earth asteroids that are about 460 feet (140 meters) or larger in size. These larger asteroids pose a much greater threat if they were to impact, and they can be detected much farther away from Earth, because they're simply much brighter than the small ones. It is thought that there are over 100 million small asteroids like 2020 SW, but they are hard to discover unless they get very close to Earth.

"The detection capabilities of NASA's asteroid surveys are continually improving, and we should now expect to find asteroids of this size a couple days before they come near our planet," added Chodas.

A division of Caltech in Pasadena, JPL hosts CNEOS for NASA's Near-Earth Object Observations Program in NASA's Planetary Defense Coordination Office. More information about CNEOS, asteroids, and near-Earth objects can be found at: **https://cneos.jpl.nasa.gov**

NASA/JPL-Caltech

*This illustration shows a near-Earth asteroid like asteroid 2020 SW traveling through space.*

# Joe Pengilley, former technician, dies at 85

Joe Pengilley, a former center technician, died June 18. He was 85.

People who knew Pengilley said he was a talented technician, a friend and mentor to all he met, and a rare individual who lightened everyone's day and made work fun.

Before Pengilley began his work at the center, he was part of a construction crew that erected Building 4800.

During his more than 50 year career at NASA Armstrong, he was a civil servant and later a contractor.

He began his federal career with National Advisory Committee of Aeronautics (NACA) on Jan. 20, 1955, where he worked in the calibrations laboratory and was instrumental in supporting projects such as the X-15 program.

In 1979 Pengilley transferred to the machine shop where he retired as a civil servant in 1991. He was rehired in the machine shop as a contractor until 2005, when he retired at 71.

# David Stoddard, former engineer, dies at 96

David Stoddard, a former center engineer on projects like the rocket-powered X-15 and the Lunar Landing Research Vehicle, died Sept. 20. He was 96.

He worked at Edwards Air Force Base on the Regulus 1 and 2 Cruise Missile flight test programs prior to working at NASA. In 1961, he accepted a position as a rocket engine technician at the center on the X-15. He participated in numerous research programs, such as the Lunar Landing Research Vehicle before retiring in 1984.

Stoddard often attended the NASA Armstrong Retiree Breakfast in Lancaster. People who knew him said he was an interesting and sincere person, a good conversationalist and was very knowledgeable about NASA and military history.

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