National Aeronautics and Space Administration

THE SPARK

TECH TRANSFER, PARTNERSHIPS, AND SBIR/STTR AT GODDARD

CONTENTS

About the cover:

The James Webb Space Telescope's mirror undergoes center of curvature testing, October 2016.

NASA/Chris Gunn

OFFICE OF THE CHIEF

The COVID-19 pandemic may have continued to throw curveball after curveball our way, but here at the Strategic Partnerships Office (SPO), we are proud to say that we continued to find creative ways to keep engaging with the community, transferring Goddard technologies, and fostering innovation.

During the past year, we saw several successful launches, including those for high-profile missions several years in the making. Multiple CubeSats were launched alongside Landsat 9, demonstrating the benefits of ride sharing to launch efficiency. We also witnessed the launch of Lucy, the first mission to the Trojan Asteroids, carrying Goddard-developed instrumentation such as L'Ralph, a color visible imager and infrared spectrometer that will study the asteroids' surfaces.

2021 was a big year for space telescopes. We celebrated 31 years of Hubble and commemorated the launch of the long-awaited James Webb Space Telescope (JWST). Webb is not only the biggest and most powerful space telescope ever launched, but also the culmination of years of collaboration and innovation across the globe. Webb's development led to the creation of incredible technologies and was the driving force behind many NASA spinoffs to other industries, something we at SPO are incredibly proud of.

Finally, we also celebrated accomplishments closer to home. Dennis Andrucyk, our Center Director, won the Federal Labs Consortium (FLC) Mid-Atlantic Region Award for Laboratory Director of the Year. One of our previous Technology Managers, Eric McGill, also won in the Outstanding Technology Transfer Professional of the Year category, thanks to his contributions to SPO and the technology transfer community at large.

Read on for more stories on this year's launches, Goddard's work in upcoming missions, the many examples of successful partnerships, and SPO's accomplishments in technology transfer, software release, and more.

Darryl R. Mitchell, Chief

Strategic Partnerships Office
NASA's Goddard Space Flight Center

THE GODDARD LAUNCHES

A United Launch Alliance Atlas V rocket launches the Lucy spacecraft from Space Launch Complex 41 in October 2021

Photo credit: NASA/Bill Ingalls

MISSION ACCOMPLISHED

Despite the challenges of an ever-evolving pandemic, the Goddard community still came together to achieve the incredible throughout the 2021 fiscal year. From improvements to SmallSat technologies to the launch of NASA flagship missions such as the James Webb Space Telescope, Goddard innovators, collaborators, and partner organizations continued to create and innovate undeterred by the many obstacles along the way.

The Hubble Flight Operations Team at Goddard adapts to the COVID-19 pandemic with telework, limited personnel on site, masks, and social distancing. Credit: NASA/Goddard/Rebecca Roth

2021 was a busy year for Goddard. The global pandemic notwithstanding, it was a time of launches big and small (and, in some cases, both at once!), the continuation of legacies decades in the making, and pushes for great innovation and advancement on all fronts. The year saw the launch of Landsat 9 with a brand new, secondary payload adapter carrying multiple CubeSats stowed away inside. It brought us the launch of Lucy, the first ever spacecraft sent to the Trojan Asteroids in a lonely, 530-million-mile journey beyond Jupiter. It also heralded the start of a new generation of space observations with the long-awaited launch of JWST. Each of these missions and all other missions past, present, and future brings about new innovations, new technologies, and new partnerships. The Strategic Partnerships Office is proud to present some of them in this publication.

LANDSAT 9

BUILDING LEGACIES OLD AND NEW

Image credit: NASA

The first Landsat launched in 1972, and since then, the line has become a major partnership mission between NASA and the U.S. Geological Survey (USGS), providing more than 10 million stunning images of Earth's surface . The Landsat line of satellites has provided data and insights into Earth's systems for nearly 50 years, curating the longest continuous global record of Earth's surface changes.

This legacy continued aboard an Atlas V rocket on September 27, 2021, with the launch of Landsat 9. The satellite joins its nearly identical predecessor, Landsat 8 (launched in 2013) and replace Landsat 7 (launched in 1999). In orbit, the two satellites collect images from across the planet with an eight-day phase difference.

Continuous data collection is one of the cornerstones of Landsat missions. As such, to reduce build time and prevent data gaps, the design of Landsat 9 is largely similar to Landsat 8. Though both satellites have higher imaging capacity than their predecessors and carry similar instruments, Landsat 9 sensors are able to detect a higher range in intensity depending on spectral band.

Upgraded instruments and higher resolution imaging were not the only additions or modifications to the latest Landsat. Unlike all others before it, Landsat 9 was the first to carry multiple CubeSats stowed away in a ring-shaped object tucked into the new Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) Flight System (EFS).

The EFS, developed by the U.S. Space Force Mission Manifest Office, traveled to space alongside Landsat 9, enabling the simultaneous launch of multiple CubeSats in an approach known as rideshare.

The rideshare concept is self-explanatory. Smaller spacecraft catch a ride on another, larger spacecraft's payload, maximizing launch vehicle efficiency. Getting multiple spacecrafts in orbit with a single launch vehicle relies on tremendous cross-organizational collaboration and coordination to prevent any negative impact to the success of the primary payload.

"Do no harm to the primary mission...that is our top requirement," says Theo Muench, the project manager for the Landsat 9 ESPA Flight System.

Rideshare has presented its fair share of unique challenges. In the case of Landsat 9, obstacles involved not only ensuring the CubeSats posed no hazards to the satellite on ascent, but also aligning multiple mission schedules to a single launch date. The EFS team used mass simulators to mimic the shape and weight of the added CubeSats to demonstrate their impact—or lack thereof—to the primary payload.

"If there's a problem it's clear that we can protect the primary mission," Muench says. The use of mass simulators allows teams to continue meeting primary mission timelines, even when secondary missions experience delays or setbacks. "We're demonstrating that mass simulator replacement is a practical and effective contingency plan."

Two of the CubeSats catching a ride with Landsat 9 were sponsored by the CubeSat Launch Initiative, based out of NASA's Kennedy Space Center. The Cusp Plasma Imaging Detector (CuPID) from Boston University will study the interactions between solar wind and Earth's magnetic field, while the Colorado Ultraviolet Transit Experiment (CUTE) from the University of Colorado, Boulder, will study exoplanet atmospheres.

The successful launch of a flagship mission such as Landsat 9 with a secondary CubeSat payload marks a turning point in SmallSat missions. These missions have evolved considerably since the first CubeSats emerged in the late 1990s with the streamlining of the SmallSat platform. Thanks to the miniaturization of scientific instruments, Goddard engineers have developed new SmallSat components and technologies, increasing the missions' reliability while reducing cost.

As demonstrated by the ESPA Flight System, rideshare is the next step in cost reduction and improved launch efficiency. As this approach evolves and launch coordination improves, secondary CubeSat payloads will likely become passengers in future missions

Landsat 9 being encapsulated in its two fairing halves, with the CubeSat payload adapter ring at the bottom. Photo Credit: NASA/KSC/Randy Beaudoin

LUCY, FIRST TO THE TROJANS

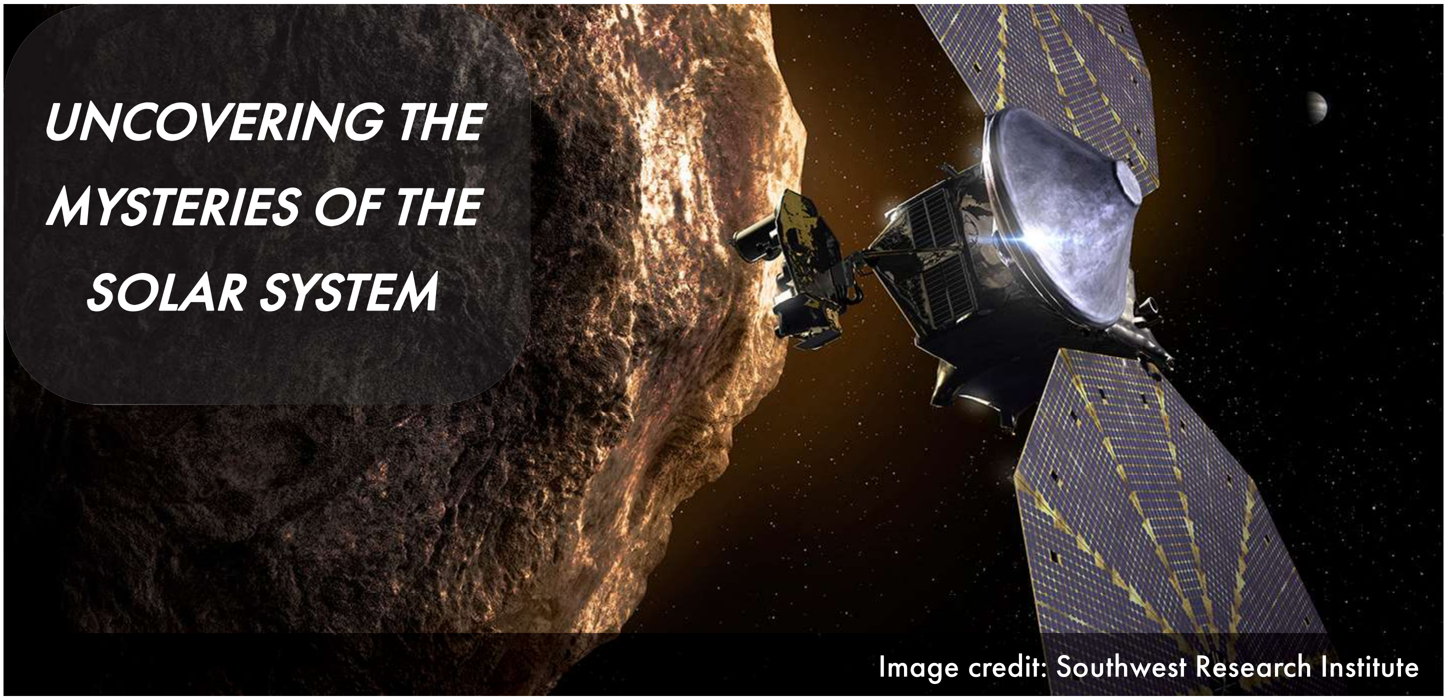


Image credit: Southwest Research Institute

Lucy, NASA's first-ever mission to the Trojan Asteroids, successfully launched aboard a United Launch Alliance (ULA) Atlas V rocket on October 16, 2021. The launch marked the start of a 12-year long, 530-million-mile journey to the vicinity of Jupiter.

Lucy's goal? To uncover the mysteries of the formation of our Solar System.

The swarms of asteroids known as the Trojans orbit the Sun in two loose groups in Jupiter's path, one leading ahead of the gas giant, the other trailing behind. Planet formation and evolution models suggest that the Trojans are composed of the same primordial material that formed the outer planets (Jupiter, Saturn, Uranus, and Neptune). This makes these asteroids perfect time capsules providing vital clues to the mysteries of the birth of our Solar System, over four billion years ago.

To study these Solar System time-capsules, Lucy carries a suite of remote-sensing instruments:

Terminal Tracking Camera (T2CAM)

Lucy's T2CAM will assist with navigation and tracking by keeping the asteroids in the field of view of the main instruments. It will also take wide-field images of the asteroids to better identify their shapes.

Lucy Thermal Emission Spectrometer (L'TES)

Built by a team at Arizona State University (ASU), L'TES will detect infrared radiation to take temperature measurements at several points of an asteroid's surface, combining them to provide insights to the asteroid's physical surface properties.

Lucy Long Range Reconnaissance Imager (L'LORRI)

Lucy's most sensitive and highest resolution camera is a type of telescope, using hyperbolic mirrors to reflect and focus light through a set of lenses. L'LORRI's main objective is to produce clear images of the Trojans despite an extremely dark environment.

L'Ralph

The L'Ralph instrument will search the Trojans' surfaces for organic compounds, ices, and hydrated minerals. Developed at Goddard, it is actually two instruments in one: a color visible imager, or MVIC (Multispectral Visible Imaging Camera) and an infrared spectrometer, LEISA (Linear Etalon Imaging Spectral Array). To limit the number of moving parts in the instrument and reduce the risk of part failure, the L'Ralph team at Goddard, constructed it out of a single block of aluminum. In lieu of a focusing mechanism, the instrument counts on the equal rate of expansion and contraction of the aluminum at certain temperatures to keep its optical system in focus.

Goddard innovators also contributed to L'Ralph, improving on mechanical heat switches to assist in the instrument's temperature transitions in thermal vacuum tests and minimize thermal disturbances during testing.

Lucy is the thirteenth standalone mission in NASA's Discovery program and included the collaboration of NASA centers (Kennedy, Marshall, and Goddard), Lockheed Martin, and the Southwest Research Institute (SwRI), as well as other partner institutions.

In a sense, the mission is an archaeological dig of sorts, searching for unique, never-before seen "fossils" of the remnants of our early Solar System. Lucy was named after the eponymous fossilized skeleton of an early human ancestor found in Ethiopia in 1974, which provided unique insights into human evolution. Similarly, the Lucy spacecraft aims to revolutionize our understanding of planetary origins and even life on Earth.

During its 12-year journey (NASA's longest primary mission yet), Lucy will visit a total of eight distinct locations: seven Trojan asteroids and one main belt asteroid. No other space mission in history has traveled to as many different destinations in independent orbits around the Sun. Lucy's complex path is made possible by an "opportunistic trajectory" dictated by celestial mechanics, taking into consideration the orbits, sizes, and types of asteroids "trapped" in the distinct swarms at Lagrange Points 4 and 5. Additionally, Lucy's Instrument Pointing Platform provides significant flexibility to the spacecraft, allowing its instruments to point at the Trojan asteroids during high-speed fly-byes, all while keeping the high gain antenna pointed towards Earth.

Before it even makes it to the Trojans in 2025, Lucy will fly by Earth for two gravity assists in 2022 and 2024 respectively, returning once more for a third assist in 2030. Lucy's primary mission will end in 2033, but it will remain in a stable orbit, revisiting the Trojan Asteroids every six years for thousands, if not millions of years.

Artist's concept of the Trojans, showing the trailing asteroid packs in orbit with Jupiter. Image credit: NASA/JPL-Caltech

JAMES WEBB SPACE TELESCOPE

Launched on Christmas morning, 2021, the James Webb Space Telescope (JWST) was a massive undertaking decades in the making. Webb is a testament to great technological advancements that would not have been possible without the collaboration and participation of hundreds of partners and thousands of individuals across NASA and around the globe.

Though construction of various individual components—such as its 18 hexagonal mirror segments—began in 2004, Webb would spend a significant portion of its life on Earth at Goddard. From 2012 to 2017, many of these components were assembled, installed, and tested at GSFC, counting with the contribution of several innovators and partner organizations.

GODDARD TECH TRANSFER CONTRIBUTIONS:

74 total New Technology Reports (NTRs) related to the Webb mission submitted since construction began, with several spinoffs to other industries and daily life.

Nine partnership agreements executed, with partners in several fields ranging from aerospace to academia.

Five Goddard Spinoffs to manufacturing, health and medicine, and industrial productivity.

SBIR grants funded innovations such as QED Technologies' sub-aperture stitching interferometer (SSI) and aspheric-stitching interferometer, advancing optics measuring and manufacturing.

Continued on page 14

Mirrors on a James Webb Telescope array undergo cryogenic testing.
Credit: NASA/MSFC/David Higginbottam/Emmett Given

COMING SOON

PACE: 2023

NASA's Plankton, Aerosol, Cloud, & Ocean Ecosystem mission aims to expand and improve the agency's 20-year record of satellite observations of ocean biology, aerosols, and clouds. PACE will assess ocean health by measuring the distribution of phytoplankton and continue systematic records of key atmospheric variables associated with air quality and climate. It will have two primary science instruments:

Ocean Color Instrument (OCI): Spectrometer used to measure intensity of light over portions of the electromagnetic spectrum. It will be the most advanced instrument for observing ocean color in NASA's history, enabling continuous measurement of light at finer resolutions than any previous NASA ocean color sensors.

Multi-angle Polarimeters: these radiometers will measure the oscillation of sunlight within a geometric plane and how it changes when passing through clouds, aerosols, and the ocean. They will provide detailed information on the atmosphere and the ocean.

PACE

LISA: 2037

The Laser Interferometer Space Antenna is a space-based gravitational-wave observatory consisting of three spacecraft separated by millions of miles in space, relaying laser beams between one another and comparing signals to search for gravitational wave signatures from distortions of spacetime. The study of gravitational waves shows great potential for discovering parts of the universe that are invisible by other means, such as black holes, the Big Bang, and other as of yet unknown objects.

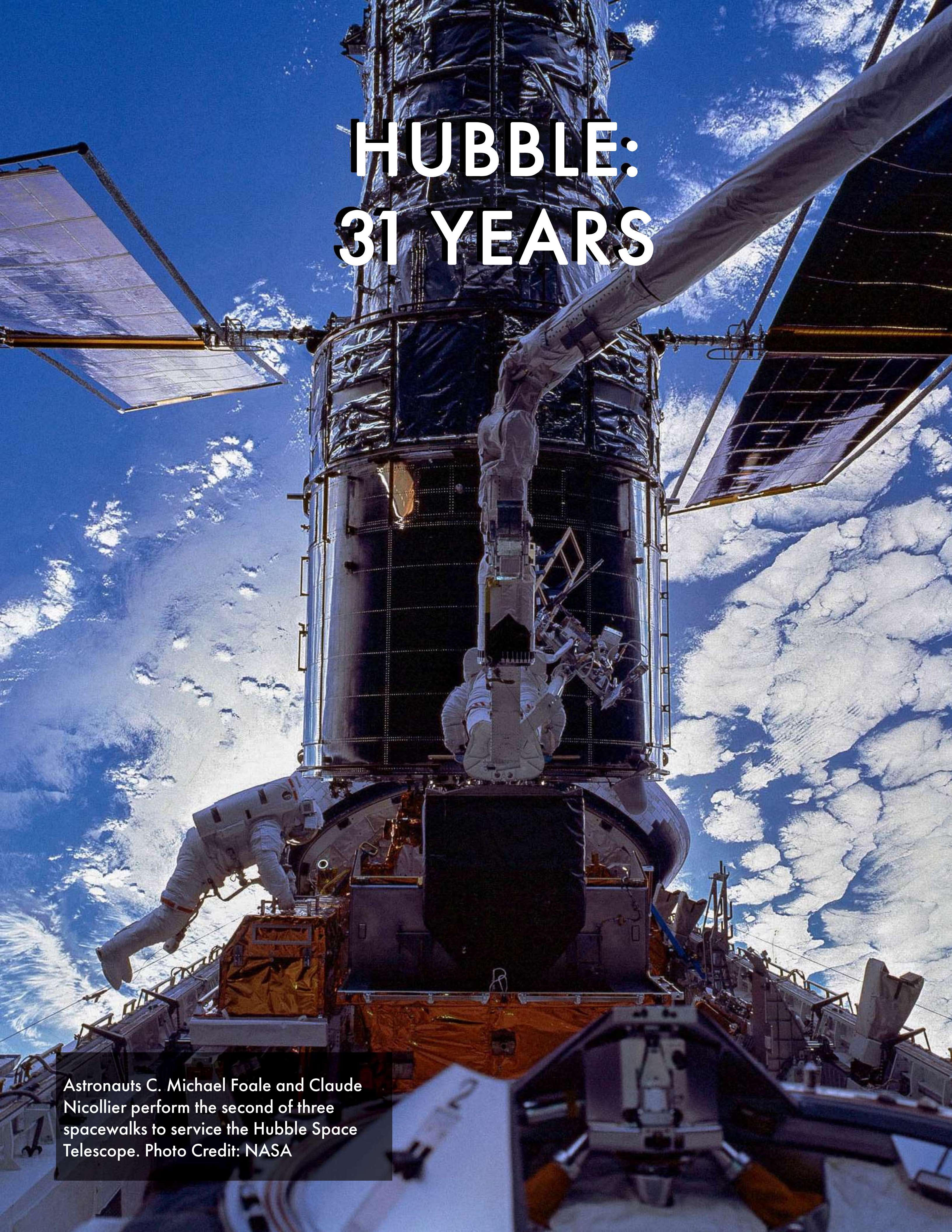
The mission is led by the European Space Agency (ESA). NASA supports both the ESA and an international consortium of scientists by providing science and engineering expertise, technology development, and interface with the U.S. research community.

NASA is developing key technologies for possible contribution to the LISA mission. For instance, the LISA telescope and laser systems are being developed at Goddard Space Flight Center, and a Charge Management System is under development by the University of Florida.

As of 2021, Goddard has completed the first prototype laser, building upon the technology used in the Gravity Recovery and Climate Experiment (GRACE) mission.

esa

HUBBLE: 31 YEARS



Astronauts C. Michael Foale and Claude Nicollier perform the second of three spacewalks to service the Hubble Space Telescope. Photo Credit: NASA

THE HUBBLE LEGACY

Since its launch in 1990, the Hubble Space Telescope has revolutionized astronomy with its unprecedented clear view of the universe. Hubble's contributions to science and technology have been both numerous and varied, on and off Earth.

Hubble's discoveries have confirmed the existence of black holes in galaxy cores, measured exoplanet atmospheres, found the most distant galaxies ever observed, and led to a Nobel Prize winning discovery in 2011 by verifying the accelerating expansion of the universe.

As a serviceable telescope, Hubble's capabilities have grown and adapted over its three decades of operation. During that time, Hubble has made over 1.5 million observations, looking back as far as 13.4 billion light-years from Earth.

Hubble's first-ever servicing mission, STS-61, had the objective of correcting the telescope's optics. Shortly after launch, operators discovered a flaw in its primary mirror, which affected the clarity of Hubble's first images. In 1993, astronauts aboard the space shuttle Endeavor installed the Wide Field and Planetary Camera 2 and the Corrective Optics Space Telescope Axial Replacement (COSTAR) instrument.

Hubble would be serviced in orbit a total five times over four servicing missions from 1993 to 2009. Upgraded instruments and improved technology have kept Hubble scientifically productive well beyond its original expected lifespan of 15 years, paving the way for countless discoveries and advancements.

DISCOVERIES

Hubble's wealth of data has led to major scientific discoveries, expanding our understanding of the universe, and even raising new questions and theories along the way. Every current astronomy textbook includes contributions from Hubble, and nearly 20 thousand peer-reviewed science papers on its discoveries have been published.

Among many other discoveries, Hubble has studied objects in the outer reaches of the Solar System (such Pluto and Eris), witnessed the reappearance of supernovae , determined the size and mass of the Milky Way, and identified the farthest known galaxies to date. The observatory was also able to support black hole hypotheses from the early 1960s by showing that black holes are commonly found in the center of galaxies.

Hubble's measurements have answered several questions, but they have also paved the way for new theories. For example, observations have helped astronomers refine not only the universe's age, but also its rate of expansion. However, with the assistance of ground-based observatories, Hubble was able to provide evidence that the universe is not only expanding but accelerating—a discovery worthy of the 2011 Nobel Prize in Physics. The phenomenon is generally attributed to dark energy, the nature of which is a complete mystery to astronomers.

TECHNOLOGY TRANSFER

Hubble's contributions over its three decades of operation go far beyond its observations of the universe. The innovations created by Hubble's development, operations, and servicing have led to technological advancements in several fields and industries, from ultra-precision optics for orbiting telescopes to software used to track the populations of endangered animals.

In imaging technology, charge coupled devices, or CCDs, are most commonly used to allow us to see near-infrared light. These silicon chips connect light directly into electronic or digital images that can later be manipulated or enhanced by computers. The technology enables Hubble to convert raw data into images and has been improved and adapt-

A higher-resolution image of galaxy NGC2903 taken in 2021. Hubble first visited this spiral galaxy in 2001, before its updated cameras were installed. Photo credit: ESA/Hubble, NASA

ed for different industries.

A commercially available CCD virtually identical to Hubble's was used in the LORAD Stereo Guide Breast Biopsy System by LORAD Corporation. The digital mammography system adapted and incorporated Goddard-developed CCDs to image breast tissue more clearly and efficiently.

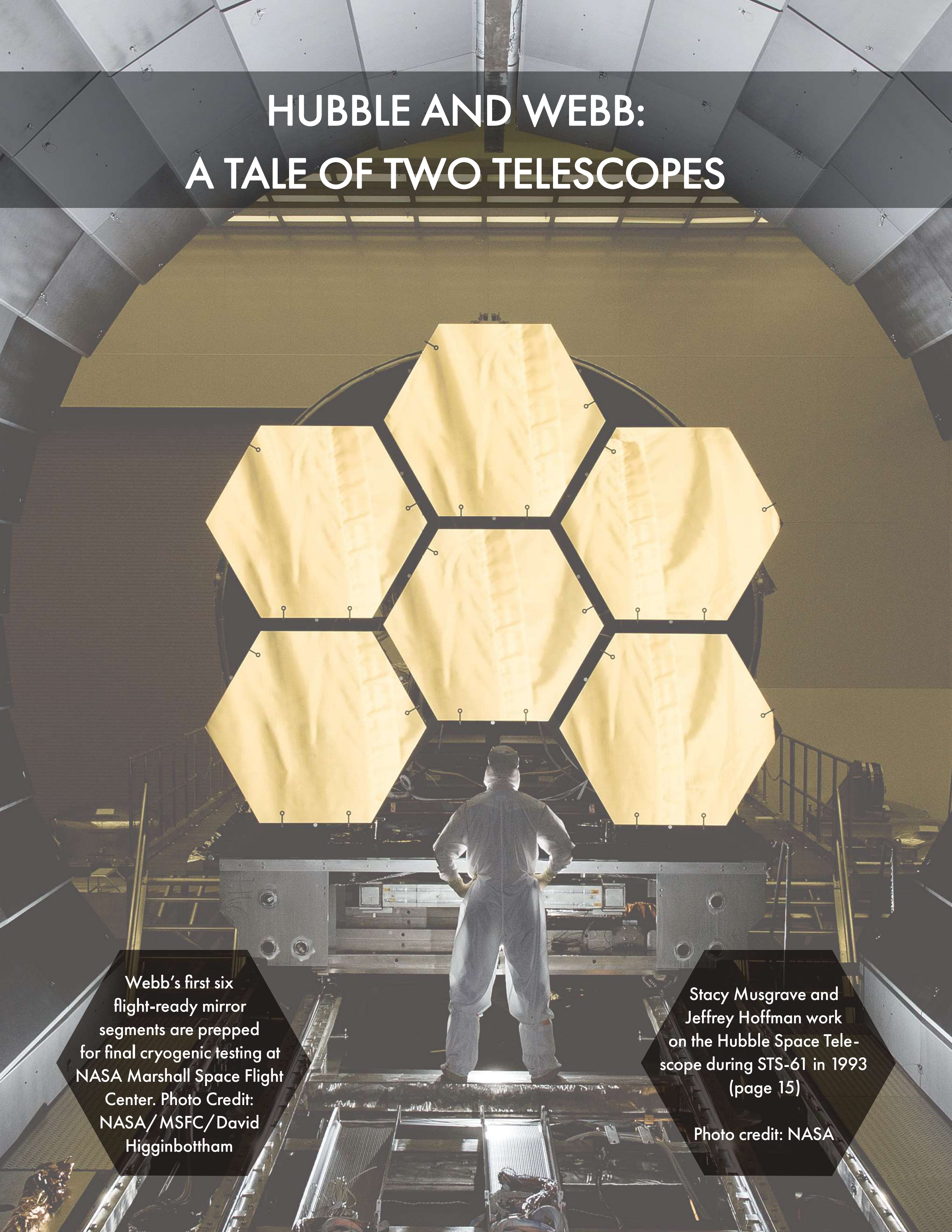
CCDs have also been used to monitor the deterioration of historical documents. A photometer, or a CCD detector, can detect changes in contrast, shape, or other degradation indicators with up to ten times the sensitivity of the human eye. The National Archives have used it to monitor the degradation of historical documents such as the Declaration of Independence and the Constitution of the United States. It has also been used to view ancient document fragments in longer wavelengths beyond the sensitivity of infrared film. With the resulting increase in contrast, researchers at the Getty Conservation Institute were able to view degraded, previously unseen writings in the Dead Sea Scrolls.

In the superpolishing optics field, innovations and improvement to the ultra-precise mirror technology have contributed to the advancement of microlithography. Innovations in optics were also used to develop new tools and methods for sharpening speed skates, inspired by the principles used to create optics for Hubble.

Hubble also brought software innovations to other fields. For example, the scheduling software created to assist in Hubble's operations has been employed to streamline semiconductor manufacturing operations and has optimized dynamic rescheduling in hospitals.

Even algorithms used to map the stars found applications on Earth. The pattern-matching algorithm created for Hubble was adapted into a computer-based tracking system to gather data on endangered animal populations. The program allows anyone, from researchers to tourists, to submit animal photographs for comparison and identification online.

HUBBLE AND WEBB: A TALE OF TWO TELESCOPES



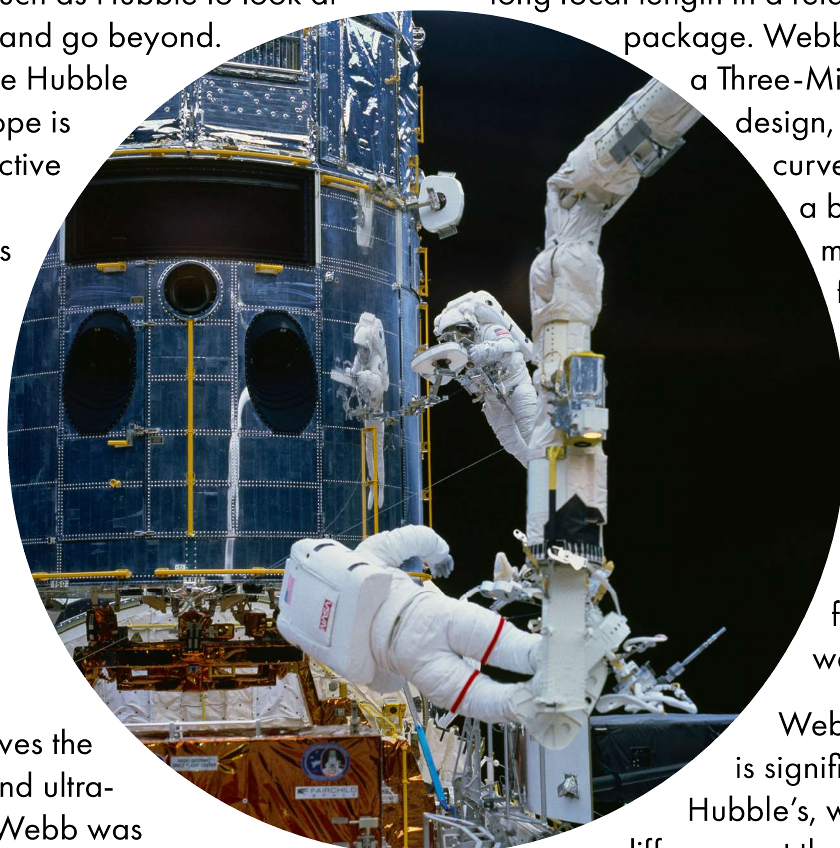
Webb's first six flight-ready mirror segments are prepped for final cryogenic testing at NASA Marshall Space Flight Center. Photo Credit: NASA/MSFC/David Higginbottham

Stacy Musgrave and Jeffrey Hoffman work on the Hubble Space Telescope during STS-61 in 1993 (page 15)

Photo credit: NASA

The Hubble Space Telescope has given us great insight into our universe, providing clear, detailed views reaching farther out in space and further back in time than any of its predecessors. Now, after a successful Christmas morning launch in 2021, the James Webb Space Telescope is poised to go further and see farther than ever before.

With that comparison, it is easy to see why Webb is often called Hubble's "replacement." However, it is more like a successor. Webb stands on the shoulders of giants such as Hubble to look at longer wavelengths and go beyond. Webb does not make Hubble obsolete. The telescope is still incredibly productive even after three decades in orbit, thanks to servicing missions that have upgraded its instruments along the way. More than anything, the two telescopes will complement one another, as their capabilities are not identical by design.



While Hubble observes the universe at optical and ultraviolet wavelengths, Webb was designed to look at the universe primarily in infrared. Hubble does have limited infrared capability, but Webb's wavelength coverage is far broader, with only limited capability in the visible range. In simpler terms, Webb is able to see much more distant objects than can be seen in the spectral bands covered by Hubble.

Unlike Hubble, which is a low-orbit, serviceable telescope (the only of its kind), Webb will travel much, much farther, to the gravitationally stable Lagrange Point 2, at about 1.5 million kilometers from the Earth. With its instrumentation, at this distance, Webb will be able to observe the first stars and galaxies formed in the early universe. Its deeper infrared will be able to cut though the dust and gas of massive clouds resulting from the formation of stars and planetary systems.

Both Webb and Hubble use curved mirrors instead of lenses, but their similarities end there as far as reflecting telescopes go. As a Cassegrain-design telescope, Hubble uses a large, concave primary mirror and a smaller, convex secondary mirror directly above it, offering a long focal length in a relatively compact package. Webb, on the other hand, a Three-Mirror-Anastigmat design, features a tertiary curved mirror to achieve a better optical performance over a wider field.

Hubble's primary mirror is made of a single piece of Ultra Low Expansion Glass® with a thin layer of aluminum for reflectivity and weighs nearly a ton.

Webb's primary mirror is significantly larger than Hubble's, which makes all the difference at the longer and dimmer wavelengths of light Webb will observe. However, were it made of the same materials, it would be far too heavy to launch into orbit. That is why Webb's massive primary mirror is composed of 18 individual hexagonal segments. The segments are made from beryllium, which is both strong and light. Instead of aluminum, they are coated with a microscopically thin layer of gold, which has the added advantage of reflecting infrared light more efficiently.

JWST: INNOVATION, COLLABORATION, AND TECHNOLOGY TRANSFER

Webb's size, complexity, and power make it the most advanced space telescope ever made. An operation this complex required cutting-edge innovations and rigorous testing. From conception to development, from launch to space operations, Webb has counted on wide network of partners across the globe.

PARTNERSHIPS

JWST is an international collaboration among NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). NASA has overall responsibility for the mission with Goddard providing the Integrated Science Instruments Module (ISIM) and managing the Webb project.

The ESA provided Webb's Near Infrared Spectrograph, Mid-Infrared Instrument Optics, as well as the Ariane Launch Vehicle. The CSA provided the telescope's Fine Guidance Sensor/ Near Infrared Imager and Slitless Spectrograph.

In total, the mission relied on contributions from hundreds of collaborators including private firms, academic institutions, and industry partners across 14 countries.

TECHNOLOGIES

Webb's complexity required a great deal of innovation. For example, there are 144 release mechanisms that must work perfectly. Additionally, the observatory has 344 points of failure, 80% of which are associated with its deployment, according to lead mission systems engineer Mike Menzel.

To ensure the mission's success, several new technologies were developed, ranging from infrared detectors to thermal control systems.

MIRRORS

Webb's mirror needed to be exceptionally large and very, very cold to capture the dim infrared light from distant galaxies. It also needed to be very light. The 18 mirror segments must align themselves with incredible precision to function as a single mirror. This is possible due to six actuators attached to the back of each mirror piece, and also prevents Webb from suffering from the same issue Hubble did with its primary mirror.

Each of the 18 mirror segments is made with lightweight beryllium and coated with reflective gold. Beryllium is remarkably strong for its weight and can hold its shape across a wide range of temperatures, making it the perfect choice for a large primary mirror that functions at cryogenic temperatures (approximately -364 F).

INFRARED DETECTORS

Webb's near and mid-infrared detectors were optimized with different materials (varying rates of mercury-cadmium-telluride for the near-infrared detectors, arsenic doped silicon for the mid-infrared), ensuring they perform with the extraordinary sensitivity the observatory requires.

WAVEFRONT ALGORITHMS

Wavefront sensing and control was essential to detect and correct any errors in Webb's optics, which is especially important as all 18 mirror segments must function as one.


Engineers inspect Webb's microshutter array at Goddard. Photo credit: NASA Goddard/Chris Gunn

CRYOCOOLER

An innovative cryocooler was developed to actively cool the detectors on Webb's Mid-Infrared Instrument (MIRI), which require temperatures not attainable by passive cooling to properly operate in space.

MICROSHUTTER ARRAY

The microshutters on Webb's Near-Infrared Spectrograph (NIRSpec) each measure only 100 by 200 microns but can select many objects in a single viewing field for simultaneous high-resolution observation.

SUNSHIELD COATINGS

The individual membranes of Webb's sunshield are each as thin as a human hair. They are made of Kapton, a high-performance plastic, and coated with aluminum on their Sun-facing surfaces.

BACKPLANE

The backplane carrying all of Webb's hardware (more than 2.5 tons of it) was engineered to be incredibly steady—essentially motionless—so that the observatory's mirrors can see deep into space.

SPINOFFS

Some of the technologies developed for Webb have found further use in different industries, on Earth as well as in space.

HELPING HUMAN EYES

The wavefront sensing technology developed for Webb was adapted for medical applications, helping to scan and measure the surface of the human eye more accurately in seconds.

HUBBLE'S VIEW

Programmable cryogenic Application-Specific Circuits (ASICs) developed for Webb were used in the repair of Hubble's Advanced Camera for surveys.

NEAR-INFRARED DETECTORS

The near-infrared detectors developed for Webb's instruments are now used in several observatories, as well as science and national security missions. Early versions of these detectors have been used in other NASA missions, such as Hubble, Deep Impact, WISE, and the Orbiting Carbon Observatory.

SOFTWARE SPOTLIGHT: NAFTU

NASA's Autonomous Flight Termination Unit (NAFTU) is a game-changing technology for U.S. industry. NAFTU is capable of independently terminating an autonomous flight when it determines its rocket is off-course. As a fully automated subsystem, NAFTU introduces critical precision-enhancing features, eliminating potential human error, enforcing reliability and safety, and ultimately saving money. It essentially eliminates the need for other methods historically used to monitor launch vehicles, such as ground personnel, transmitters, telemetry receivers, and radars.

The independent, self-contained subsystem was initially developed through a four-part collaboration among the Defense Advanced Research Projects Agency (DARPA), the United States Air Force (USAF), the Federal Aviation Administration (FAA), and NASA. Then the Autonomous Flight Termination Unit (AFTU), the technology was initially funded by DARPA's Launch Assist Space Access (ALASA) program.

NASA Kennedy Space Center (KSC) and the Air Fore jointly developed the Core Autonomous Safety Software (CASS), flown on launch vehicles utilizing AFTU technology. KSC was also responsible for the development, prototyping, and testing of the AFTU hardware.

In 2020, the software (now NAFTU) was transferred from KSC to Goddard's Wallops Flight Facility, where improvements and developments continued. Goddard personnel now work on completing the development, verification, validation, and safety certification of the software. The Strategic Partnerships Office had the complex task of commercializing and distributing it.

In addition to complications associated with the original software release, the transfer from one center to another, and constantly shifting schedules during a global pandemic, NAFTU proved to be especially challenging due to additional regulations, namely ITAR (International Traffic in Arms Regulations) and EAR (Export Administration Regulations) restrictions.

"NAFTU is particularly tricky, because there are certain restrictions that make the process more complicated," says Viva Miller, a Senior Technology Manager working on the licensing and release of NAFTU. "Due to the ITAR/EAR regulations, there's the extra step of vetting each applicant."

"THE COPYRIGHT LICENSE AND SUA COMBINATION WAS UNIQUE TO NAFTU."

—VIVA MILLER, SENIOR TECHNOLOGY MANAGER

Because of the unique nature and importance of the software, as well as the scope of industry demand, SPO created new strategies to facilitate NAFTU's release. As a result, our team found an effective way to release an interim version of NAFTU while also creating a sustainable licensing strategy.

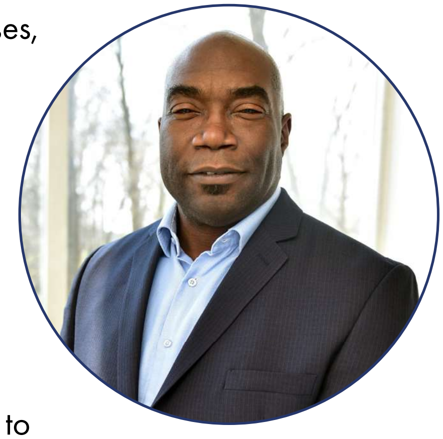
The approach, spearheaded by Miller, involved the unusual combination of a regular Software Usage Agreement (SUA) and a copyright license. To obtain the software, interested companies and government entities alike must fill out a software request form for the SUA and apply for a copyright license. NASA subsequently vets all interested parties.

"The copyright license and SUA combination was pretty unique to NAFTU," says Miller, who worked directly with developers, commercial entities, and legal representatives to successfully license the software, creating potential new licensing methods and standardized fee structures.

To date, there have been eight successfully executed licenses for NAFTU.

2021 FLC MID-ATLANTIC AWARDS

OUTSTANDING TECH TRANSFER PROFESSIONAL: ERIC MCGILL



In FY21 alone, McGill executed 18 commercial licenses, but his contributions to the Strategic Partnerships Office go far beyond that.

At Goddard since 2013, McGill has contributed enormously to the success of technology transfer at the center. His in-depth knowledge, skill, and team-based mentality were instrumental to the technology transfer program. McGill brought innovative approaches to technology transfer, such as Commercialization Training Camps targeting the professional athlete community.

Though Eric is no longer with SPO, his contributions remain pivotal to tech transfer at Goddard. Thank you, Eric!

LABORATORY DIRECTOR OF THE YEAR: DENNIS ANDRUCYK

Since becoming Center Director in 2019, Dennis Andrucyk has supported Goddard's technology transfer efforts in all fronts—from small-business partnerships all the way up to high-profile collaborative strategies.

SPO relies on the participation and collaboration of several organizations across GSFC. Andrucyk brought visibility to technology transfer and SPO's role in facilitating technology harvesting. This level of attention ensured greater cooperation and accountability across Goddard's directorates.

NASA INVENTION OF THE YEAR: COMPACT THERMAL IMAGER

The CubeSat compatible thermal imager developed at Goddard by Murzy Jhabvala, Donald Jennings, and Compton Tucker was named co-winner of the NASA Invention of the Year Award in 2021!

The CTI, patented as "Compact, High Resolution Thermal Infrared Imager" in 2019, is small enough to fit on miniaturized satellites. It was funded by NASA's Earth Science Technology Office and aided by technology developed by the Small Business Innovation Research (SBIR) program, representing many years of collaboration and innovation.

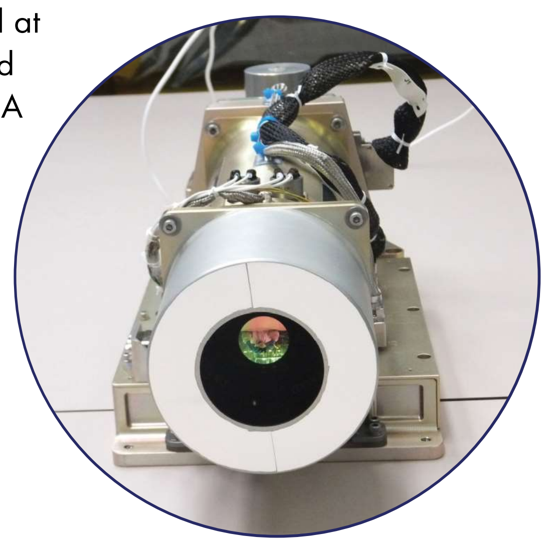


Photo credit: NASA/Murzy Jhabvala

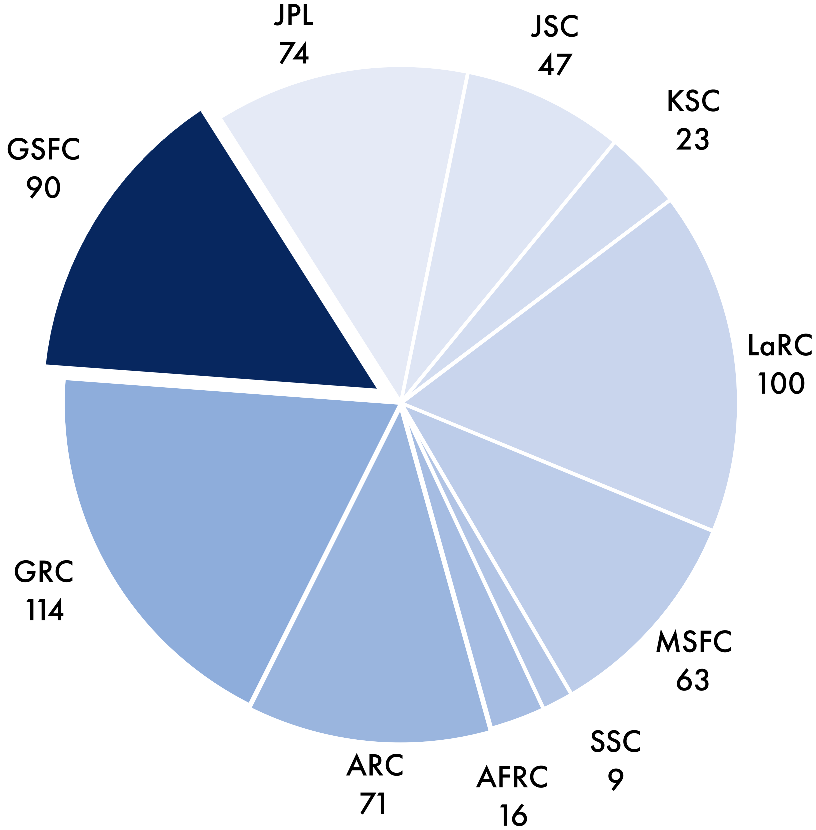
SBIR/STTR HIGHLIGHTS

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs enable small businesses to explore their technological potential by funding the research, development, and demonstration of innovative technologies.

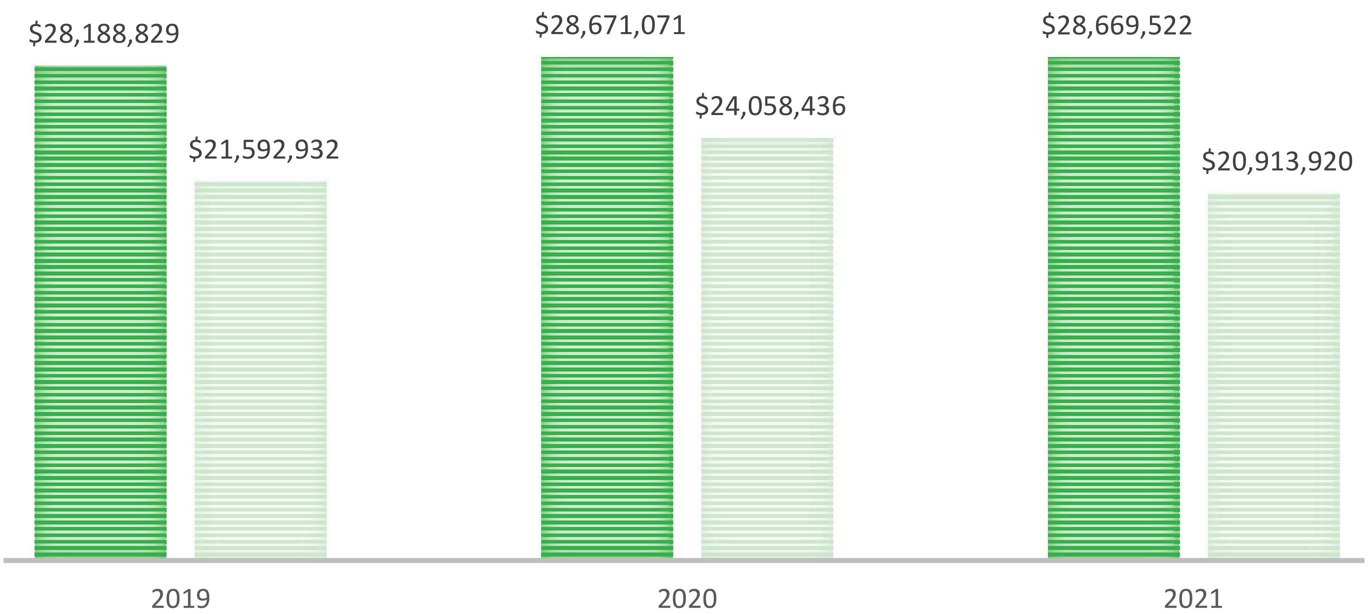
Each year, companies submit proposals to address some of NASA's specific technology needs, which are divided by subtopics. Subtopics are nominated and developed by NASA subject matter experts, helping address the agency's R&D challenges while also promoting entrepreneurial innovation.

Awards per center in CY21

Total awards: **607**



Sum of all SBIR/STTR awards per calendar year: **GSFC** and **NASA average**



Goddard was the lead NASA Center for the following research topics in 2021:

Radiation-Tolerant High-Voltage, High-Power Electronics

Flight Dynamics and Navigation Technologies

Guidance, Navigation, and Control

Technologies for Passive Microwave Remote Sensing

Particles and Fields Sensors and Instrument Enabling Technologies

Cryogenic Systems for Sensors and Detectors

Remote Sensing Instrument Technologies for Heliophysics

X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UV-OIR, and Free-Form Optics

Terrestrial Balloons and Planetary Aerial Vehicles

Command, Data Handling, and Electronics

Accelerating NASA Science and Engineering through the Application of Artificial Intelligence

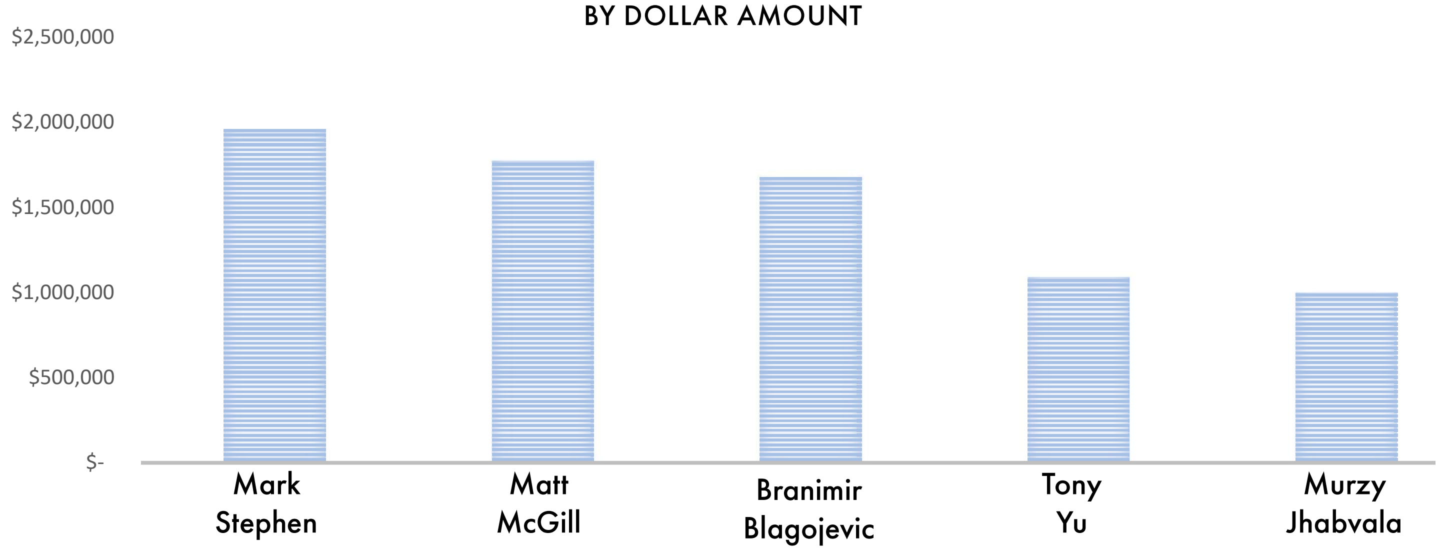
Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R)

Satellite Servicing Technologies

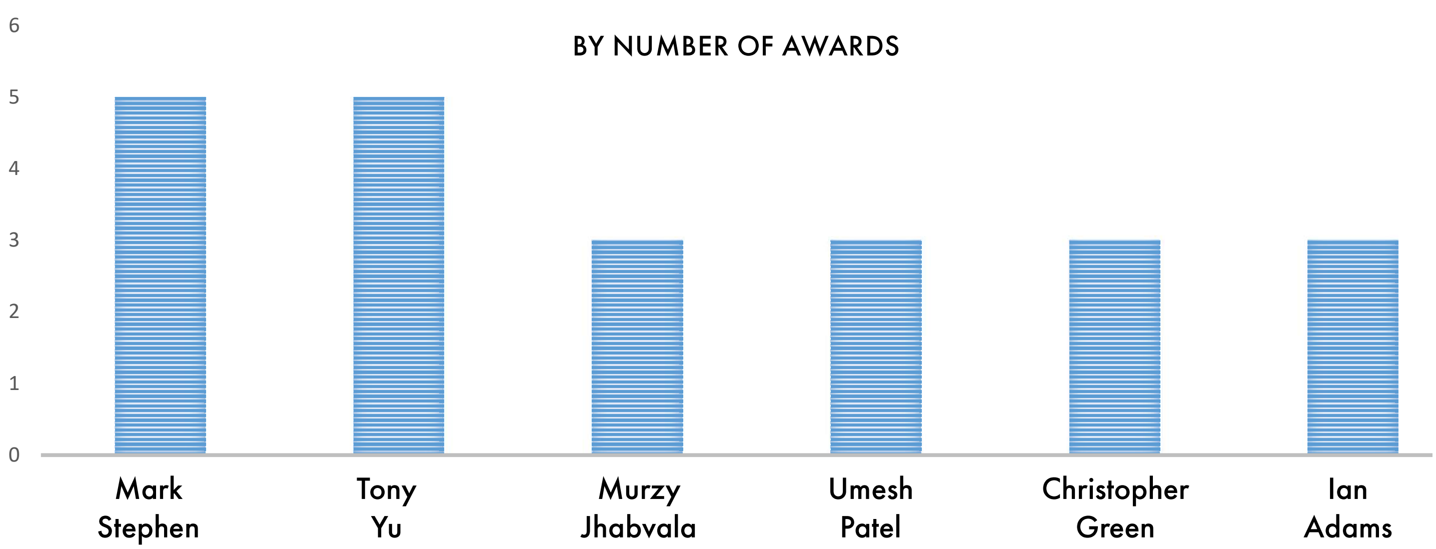
Thermal Control Systems

MOST AWARDS MANAGED IN 2021

BY DOLLAR AMOUNT



BY NUMBER OF AWARDS



THE SPARK

Goddard's The Spark shares stories about technology transfer at NASA and the innovative people who make it all possible. The magazine is published quarterly by the Strategic Partnerships Office at NASA's Goddard's Space Flight Center.

Also available online at
http://partnerships/gsfc.gov

Send suggestions to Carol Dezouzart, magazine editor:

carolina.dezouzartdrummonddemelo@nasa.gov

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