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National Aeronautics and Space Administration

KENNEDY SPACE CENTER'S

SPACEPORT magazine

#HUBBLE25

Aeronautics Research | Mars | Technology | Earth Right Now | ISS | Solar System & Beyond

KENNEDY SPACE CENTER'S

SPACEPORT MAGAZINE

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READER'S CHOICE

FRONT: In honor of the 25th anniversary of the Hubble Space Telescope, we polled the public to find out which image out of her impressive portfolio readers liked the most. With more than 1,000 likes, the star cluster Pismis 24 won by a landslide. The Spaceport Magazine staff agreed with you, our readers, and decided to give the image its rightful place on the front cover. Thank you for your input, and thank you for reading Spaceport Magazine.

Back: This image shows the dramatic shape and color of the Ring Nebula, otherwise known as Messier 57. From Earth's perspective, the nebula looks like a simple elliptical shape with a shaggy boundary. The nebula is shaped like a distorted doughnut and and has a rugby-ball-shaped region of lower-density material slotted into in its central "gap."
Photo credit: NASA

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NASA'S LAUNCH SCHEDULE

Date: No Earlier Than April 13 -- 4:33 p.m. EDT
Mission: SpaceX CRS-6 Resupply Mission to International Space Station
Description: Launching from Cape Canaveral Air Force Station, Florida. SpaceX's sixth commercial resupply mission under NASA contract to the space station will deliver several tons of supplies, including new science experiments and technology research.

Date: April 28 -- Time TBD
Mission: Progress 59P Cargo Craft
Description: The Progress resupply vehicle is an automated, unpiloted version of the Soyuz spacecraft that is used to bring supplies and fuel to the station.

Date: May 26 -- 3:46 p.m. EDT
Mission: Expedition 44 Launch to the International Space Station
Description: Kjell Lindgren of NASA, Kimiya Yui of JAXA and Oleg Kononenko of Roscosmos launch aboard a Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan, to the station.

Date: Aug. 6 -- Time TBD
Mission: Progress 60P Cargo Craft
Description: The Progress resupply vehicle is an automated, unpiloted version of the Soyuz spacecraft that is used to bring supplies and fuel to the station.

Date: Aug. 17 -- Time TBD
Mission: HTV5 Cargo Craft With CALET and MUSES
Description: The H-II Transfer Vehicle (HTV) is JAXA's unmanned cargo transfer spacecraft that delivers supplies to the station (ISS). CALorimetric Electron Telescope (CALET) is an astrophysics mission. Multi-User System for Earth Sensing (MUSES) is a precision-pointing platform that will mount externally to the station.

I am KENNEDY SPACE CENTER

Annie Caraccio

I am a chemical engineer in the Materials Science Division where I work with a dynamic group of hard-working civil servants and contractors on technology development. Most of the technology development focuses on resource reutilization and generating fuel and life support commodities for long-duration or deep-space Mars missions.

In 2009, I was selected as a NASA co-op student, which is when I began working at Kennedy Space Center. I also support the Chemical Analysis Branch during investigations for space missions such as Lockheed Martin's Orion Multi-Purpose Crew Exploration Vehicle.

In 2014, I was selected as a crew member for the Hawaii Space Exploration and Analog Simulation (HI-SEAS) 2 Mission. HI-SEAS is a Mars analog study. I simulated living on Mars in an isolated habitat with a six-person, international crew for a 120-day psychological investigation. The habitat was on the slopes of the Mauna Kea volcano at about 8,000 feet elevation. During the study, I performed various scientific research projects, including NASA's Trash-to-Gas project.

I am a graduate of the 2012 NASA FIRST leadership development program where I met and worked with some of the agency's most inspiring professionals in all different fields of the space program. At Kennedy, I co-chair the Launching Leaders early career group where we try to develop and connect young professionals both at work and within the local community. This academic year, I was able to continue my education and work towards a Ph.D. under a NASA fellowship in the Department of Chemical and Biomedical Engineering at the University of South Florida.

The people who work in the space program are some of the most motivated I have ever met, and I am privileged to work side by side with such wonderful people!

Annie

NASA's Hubble Space Telescope turns 25

By Linda Herridge

NASA's Hubble Space Telescope is a quarter-century old this month. Though only projected to be in service for 10 years when it launched aboard space shuttle Discovery on April 24, 1990, from Kennedy Space Center, the unique telescope is still a technological marvel 25 years later.

Orbiting 350 miles above the Earth and traveling at 17,500 miles per hour (5 miles per second), Hubble continues to reach back into time to capture stunning images of the universe and our own Milky Way Galaxy with its 100-inch-wide primary mirror. The telescope is credited with confirming the existence of black holes and discovering millions of galaxies and the birthplace of stars, relaying images almost too mind-boggling to comprehend.

Most recently, Hubble's observations suggest the best evidence yet for an underground saltwater ocean on Ganymede, Jupiter's largest moon. The subterranean ocean may contain more water than all of the water on Earth's surface.

"This discovery marks a significant milestone, highlighting what only Hubble can accomplish," said John Grunsfeld, associate administrator of NASA's Science Mission Directorate at NASA Headquarters in Washington. "In its 25 years in orbit, Hubble has made many scientific discoveries in our own solar system."

Former astronaut Grunsfeld made several trips to upgrade Hubble. He performed a total of eight spacewalks during Servicing Missions 3A, 3B and 4.

In January 2011, the Wide Field Camera 3 on the Hubble Space Telescope found what was thought at the time to be the most distant object ever seen in the universe. The object's light traveled 13.2 billion years to reach Hubble, roughly 150 million years longer than the previous record holder. The very dim and tiny object is a compact galaxy of blue stars that existed 480 million years after the big bang.

Frank Cepollina, who has been with NASA for 52 years, was the project manager for the Hubble Space Telescope servicing missions. He was in the Launch Control Center firing room at Kennedy for all five Hubble servicing missions.

Cepollina is a huge supporter of satellite servicing and currently is project manager for satellite servicing at NASA's Goddard Space Flight Center in Greenbelt, Maryland. He credits Lymon Spitzer, a theoretical physicist and astronomer, and Joe Purcell, a noted physicist, for first suggesting that large telescopes should be built serviceable and modular, so that science instruments and components could be changed out and problems fixed.

NASA's Marshall Space Flight Center in Huntsville, Alabama, led the design, development and construction efforts

NASA's Hubble Space Telescope heads back toward its normal routine, after a week of servicing and upgrading by the STS-109 astronaut crew aboard space shuttle Columbia.
Photo credit: NASA

of the large space telescope. Two primary contractors built Hubble. Lockheed Missiles and Space Company of Sunnyvale, California, produced the protective outer shroud and the spacecraft systems, and Perkin-Elmer Corp. in Danbury, Connecticut, developed the optical system and guidance sensors. Lockheed also assembled and tested the finished product.

Hubble's journey to space began when it arrived at Kennedy in October 1989 on a U.S. Air Force C-5A transport jet from the Lockheed Martin facility in California. Hubble was transported to the Vertical Processing Facility (VPF), where prelaunch preparations were performed. The Payload Hazardous Servicing Facility also was used for offline processing of Hubble science instruments.

"You couldn't ask for a more customer-friendly center than Kennedy," Cepollina said. "We had, on average, 200 to 300 people at the center through processing and launch, including Kennedy, Goddard, Marshall, and support contractors."

Bob Webster, NASA payload manager at the time, noted that Hubble arrived in a very unique shipping container built by the U.S. Air Force for military surveillance satellites. Hubble was transported to the pad using Kennedy's payload canister.

Webster recalled several very unusual events that occurred during processing.

The VPF was operated as a class 100k clean work area (less than 100,000 particles larger than 0.5 micrometers in size). The requirement for Hubble's sensitive instruments and lens was less than 20k. The payload processing team worked diligently to maintain the VPF at cleanliness levels between 2k and 5k. The Hubble Space Telescope Program brought with it an array of ground support equipment to test the telescope. Webster said two science instruments were installed in the telescope in the VPF.

"Normally, vertical payloads were transported to the pad before the shuttle," Webster said. "We took Hubble to the pad late in the flow to minimize its time at the pad."

The hypergolic fuel was loaded into Discovery and then Hubble was delivered to the pad and prepared for installation in the payload bay using the payload changeout room (PCR). But, hundreds of midges, a kind of small fly, had hatched and settled on the payload bay doors, resulting in an unknown number of them getting into the PCR.

Webster said the PCR doors were quickly closed and an environmental team was called in to devise a system to remove the flies. Several lighted traps with small vacuum devices and dry ice were placed throughout the clean room to collect the tiny insects, a process that took about two days.

When the PCR was clear, the eight-hour process began to install and secure the nearly 44-foot-long Hubble in the shuttle payload bay for its trip to space. Precise measurements of the bay and the telescope had been taken in advance to ensure the clearances.

On launch day April 10, pilot Charlie Bolden, now the NASA Administrator, flipped the switches on the shuttle's auxiliary power units (APU) and the launch team realized something was wrong. The flight was delayed two weeks while the faulty APU was changed out.

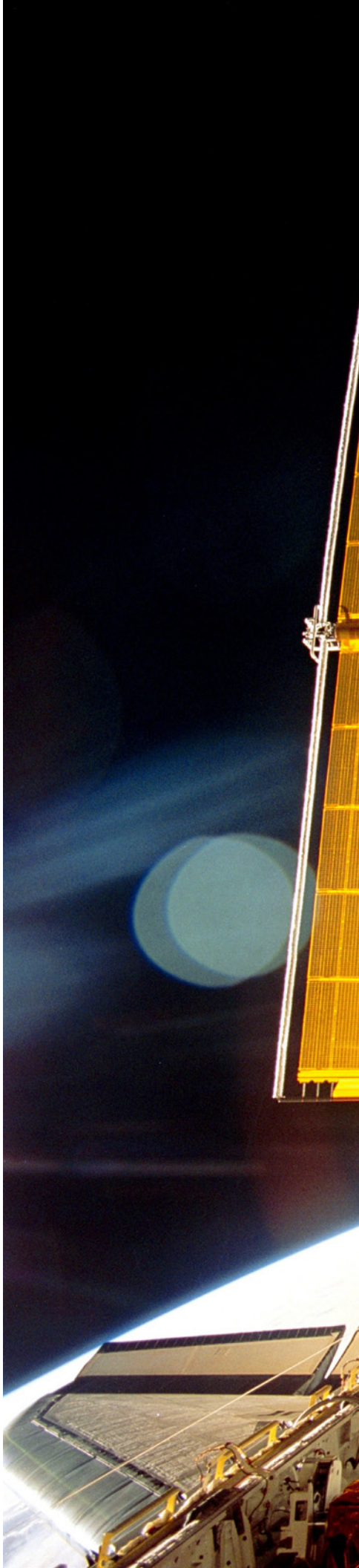
In a process that had never been planned for, the payload team removed Hubble's batteries inside the payload bay and took them to the Space Shuttle Main Engine Facility in the Vehicle Assembly Building to keep them charged. A few days before launch, the batteries were reinstalled.

"Finally seeing it launch and then deployed was an exciting experience for the entire payload processing team," Webster said. "I enjoyed working with the people on the Hubble team. I felt very proud and lucky to have this opportunity."

Before retiring from NASA in 2000, Webster worked as a division chief in the Space Station Processing Facility, planning for International Space Station segment arrival and processing.

Hubble was serviced the first time in 1993 to correct a blurred lens, and four more times to upgrade or replace several of the telescope's sensitive instruments. Each servicing mission increased Hubble's ability to reach further and further back in time and improved the clarity of the images. Each time, the space shuttle would bring back Hubble parts and equipment to be refurbished and reused.

"That first servicing mission produced the picture that everybody's seen, called the Eagle Nebula," Cepollina said. "The mission essentially was written around re-establishing the dream."



Sunlight reflects off the space shuttle Endeavour's aft windows and NASA's shiny Hubble Space Telescope before its post-servicing deployment near the end of the 11-day mission. A handheld Hasselblad camera was used inside Endeavour's cabin to record the image. Photo credit: NASA

Astronaut John Grunsfeld, STS-125 mission specialist, positioned on a foot restraint on the end of Atlantis' remote manipulator system, and astronaut Andrew Feustel (top center), mission specialist, participate in the mission's fifth and final session of extravehicular activity as work continues to refurbish and upgrade the Hubble Space Telescope. During the seven-hour and two-minute spacewalk, Grunsfeld and Feustel installed a battery group replacement, removed and replaced a Fine Guidance Sensor and three thermal blankets protecting Hubble's electronics.
Photo credit: NASA

Cepollina said there were significant societal implications through the course of the servicing program (20 years), from developing the technology to polish the optics on Hubble, which were anywhere from a dime to a quarter size in diameter, to the spherical accuracy needed to be able to correct the light coming into the telescope. The secret was an instrument called COSTAR, which had within it these corrective optics.

COSTAR also represented a great improvement in photolithography, a key process for improving transistor density on a chip. Making microchips is a function of being able to photolithographically create the individual transistors on the head of a pin. The sharper the lines, which are one one-thousandth of the diameter of a human hair, the more transistors can be placed on a pin.

More transistors increase the density of the chip, which increases computational ability and memory.

"One example: today's technology has 260,000 times more processing power (i.e. the iPhone) than the original lunar landing vehicle," Cepollina said. "It was a huge leap forward."

On the second servicing mission, the Space Telescope Imaging Spectrograph (STIS) was installed on Hubble. Using its imaging spectrograph, STIS confirmed the existence of black holes.

"One of the very first observations was the M84 galaxy, which indicated there were black holes," Cepollina said. "Because of this instrument, we now know there's a black hole in the center of almost every major galaxy in the universe that we can observe."

STIS also provided a technological push in the medical field, specifically in mammography. This instrument flew a detector that was being developed by the University of Kentucky Medical School. The school sent it to NASA to see if it could be improved upon for use on the STIS instrument. The detectors on that instrument became one of the key elements for the stereotactic breast cancer detection system.

"We did, and handed that technology back to them," Cepollina said. "A year before we launched the STIS instrument to orbit, there were more than 1,000 of these Stereoscopic Imaging breast biopsy machines in hospitals and doctor's offices around the country."

The tools developed to service Hubble were battery-operated systems, some with embedded microprocessors inside of them. Astronauts trained to use these tools. They learned how to program in the amount of speed, torque, turns and direction they wanted to accomplish the tasks.

"All they had to do was crank in the numbers, squeeze the trigger and they would get the right number of RPMs, right number of turns, right speed, clockwise or counter-clockwise motion, and out would come the bolt, or in would go the bolt," Cepollina said.

"That is automation. That is microprocessors. That was a path to robotics."

Another example was the shuttle's robotic arm used to capture Hubble for servicing and then releasing it back into orbit.

"There are two major surgical robotic systems that are in operation today from which we learned and from which they learned from NASA," Cepollina said.

The first is a machine called da Vinci, from a company called Intuitive Surgical, used to perform surgery. Another is the neuro-Arm, a Canadian-built surgical system, used to perform brain surgery on tumors. This surgical robot also can remove tumors that are growing near the central nervous system.

"Today there are more than 3,000 da Vinci machines. I recently learned that Intuitive Surgical is using the robot to remove gall bladders," Cepollina said. "Just imagine what the medical field and robotic surgery will be like in 10 years."

What's next on the horizon after Hubble?

Cepollina is studying the possibility of a 1,000-inch telescope, one with modular systems that could be built on the ground in pieces and carried on NASA's Space Launch System, with an Orion crew that could assemble it with robot arms and send it into its final orbit.

"Let's get out there and try something new. Let's get back to the basics of dreaming a dream. Even though we think it may be impossible, something may happen that makes reality click. Although the dream may be impossible, maybe the results will still be startling," Cepollina said.

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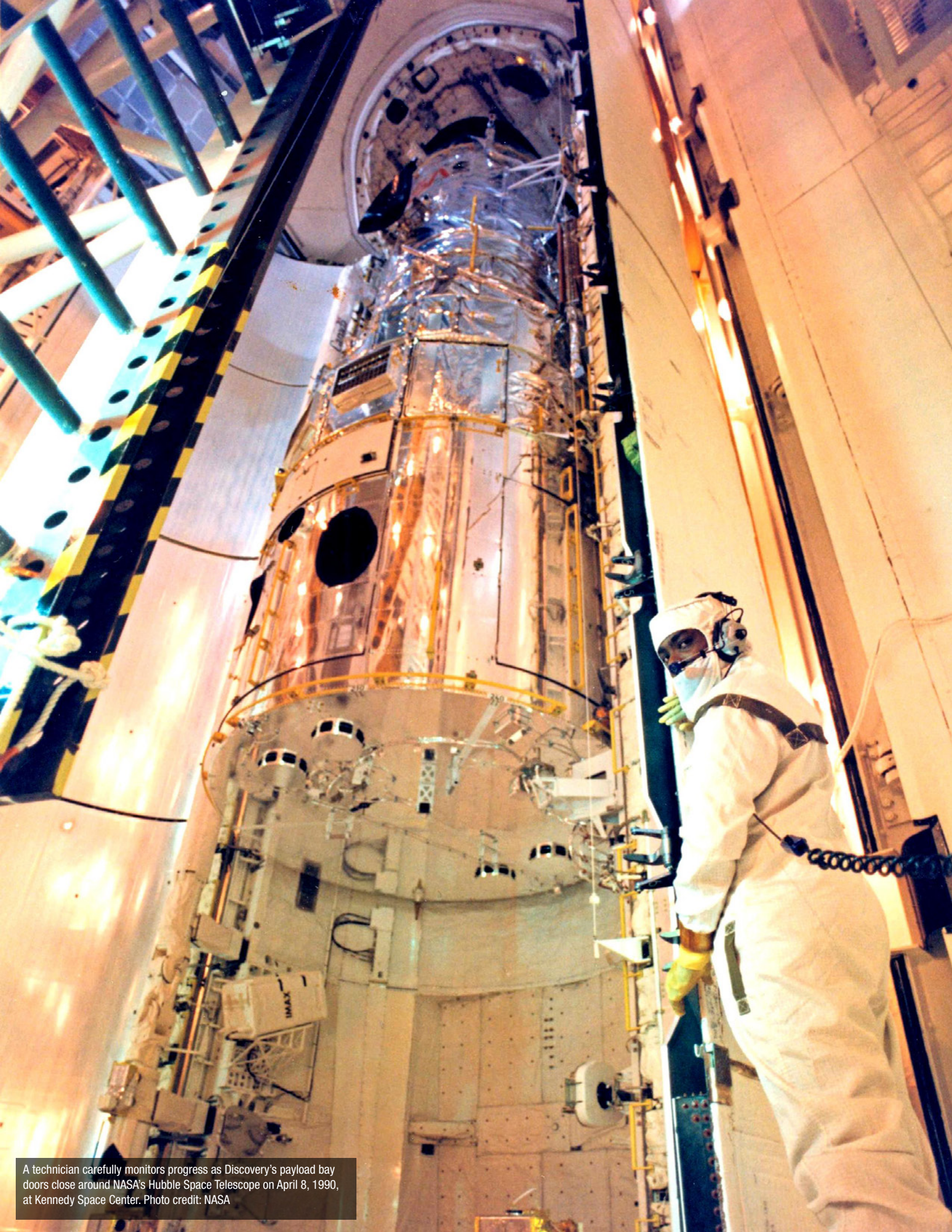
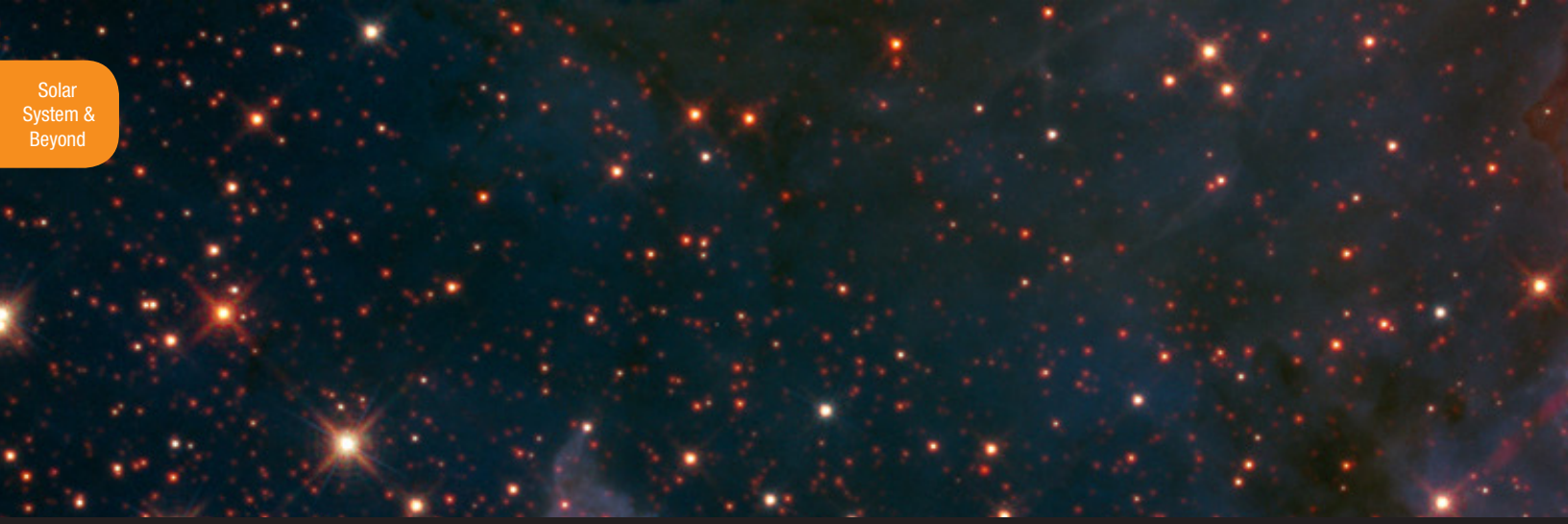
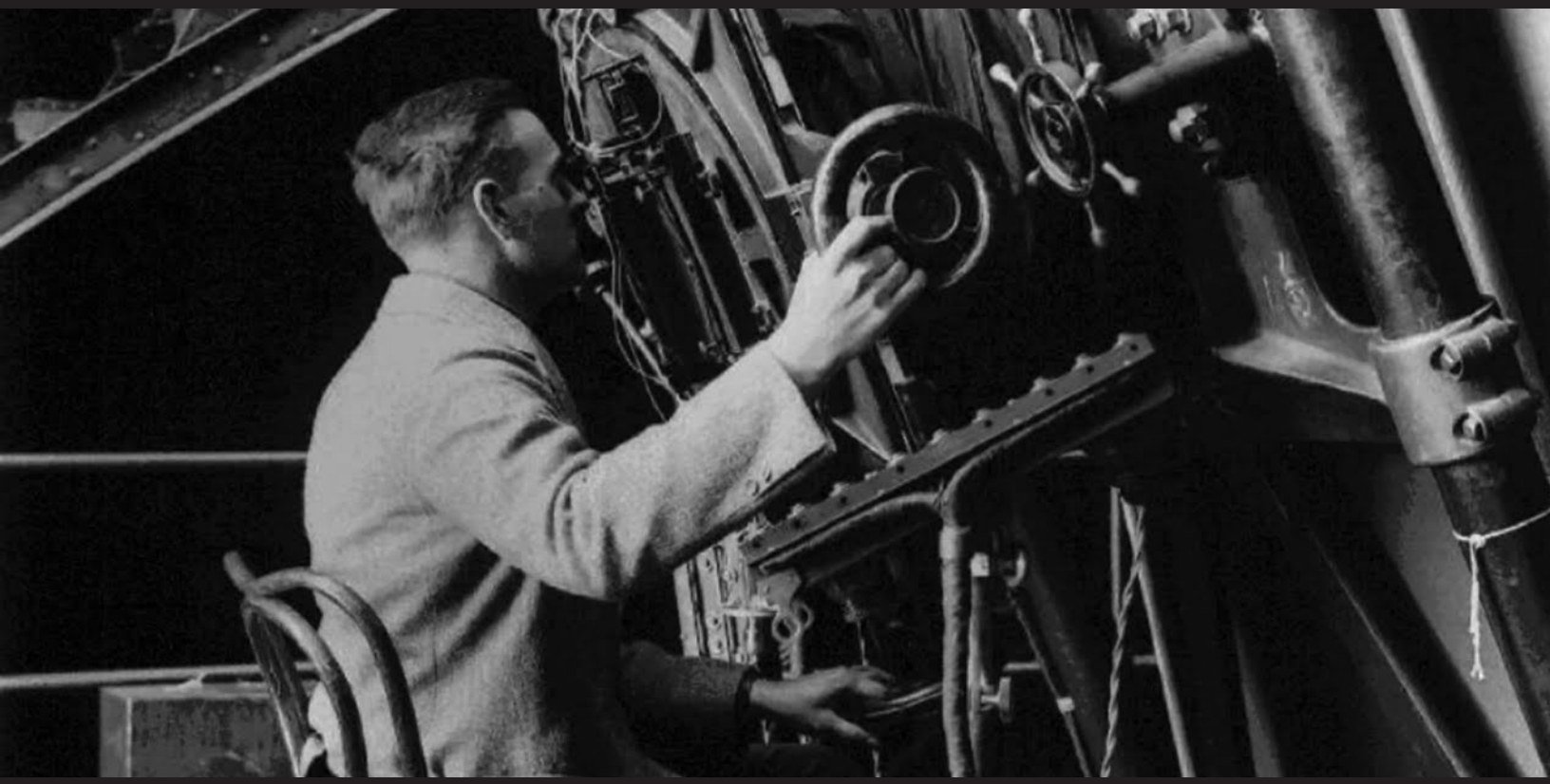


A technician carefully monitors progress as Discovery's payload bay doors close around NASA's Hubble Space Telescope on April 8, 1990, at Kennedy Space Center. Photo credit: NASA

A horizontal view of the launch of the STS-31 mission. Onboard space shuttle Discovery are the crew of five veteran astronauts and the Hubble Space Telescope. Official launch time was 8:33:51.0492 a.m. EDT. The crew included astronauts Loren Shriver, Charles Bolden Jr., Bruce McCandless, II, Kathryn Sullivan and Steven Hawley. Photo credit: NASA

This picture shows a galaxy known as NGC 6872 in the constellation of Pavo (The Peacock). Its unusual shape is caused by its interactions with the smaller galaxy that can be seen just above NGC 6872, called IC 4970. They both lie roughly 300 million light-years away from Earth. Photo credit: NASA





EDWIN HUBBLE

The man who changed astronomy

By Bob Granath

Edwin Hubble discovered the expanding nature of the universe. He also was the first to comprehend the nature of how fast galaxies move and his work became a major basis for the big-bang theory of how the universe began.

Hubble's studies at the University of Chicago focused on mathematics and astronomy, which led to a bachelor's degree in 1910. He then spent three years at The Queen's College in Oxford, England, as one of the university's first Rhodes Scholars, initially studying jurisprudence instead of science. After practicing law for one year, he decided to "chuck law" for astronomy.

"I knew that even if I were second or third rate, it was astronomy that mattered," he said.

When the United States entered World War I in 1917, Hubble rushed in his dissertation for his doctorate, then volunteered for the US Army. After the war, Hubble returned to England and spent a year in Cambridge, where he renewed his studies of astronomy.

In 1919, Hubble was offered a staff position at the Mount Wilson Observatory near Pasadena, California, where he served the remainder of his life.

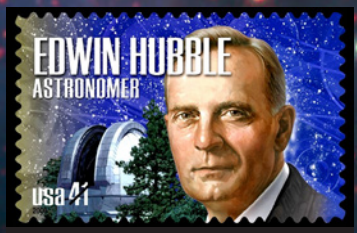
Hubble's arrival at the observatory coincided with the completion of the 100-inch Hooker Telescope, then the world's largest. At that time, the prevailing view of the cosmos was that the universe consisted entirely of the Milky Way Galaxy.

Using the telescope at Mt. Wilson, Hubble identified changes in a star used to determine its distance from the galaxy. His observations made between 1922 and 1923 proved conclusively that several spiral nebulae were much too distant to be part of the Milky Way and were, in fact, entire galaxies outside the Milky Way.

This idea was opposed by many in the astronomy establishment of the time. Despite the resistance, Hubble's findings were published in The New York Times on Nov. 23, 1924, and then more formally presented in a paper at the Jan. 1, 1925, meeting of the American Astronomical Society.

Hubble's discoveries fundamentally changed the scientific view of the universe. Among his most significant came in 1929 when he determined that the farther a galaxy is from Earth, the faster it appears to move away. This notion of an "expanding" universe formed the basis of the big-bang theory, which states that the universe began with an intense burst of energy at a single moment and has been expanding since.

Many believe had Hubble not died suddenly in 1953, his work would have been honored with that year's Nobel Prize in physics, which cannot be awarded posthumously.



On March 6, 2008, the United States Postal Service released a set of commemorative stamps designed by artist Victor Stabin honoring astronomer Edwin Hubble and three other American scientists.
Photo credit: United States Postal Service

Opposite: American astronomer Edwin Hubble uses the 100-inch Hooker Telescope on Mount Wilson near Los Angeles, California, to observe billions of other galaxies besides the Milky Way in 1924.
Photo credit: NASA

Astronomers using Hubble's data have published more than

12,700

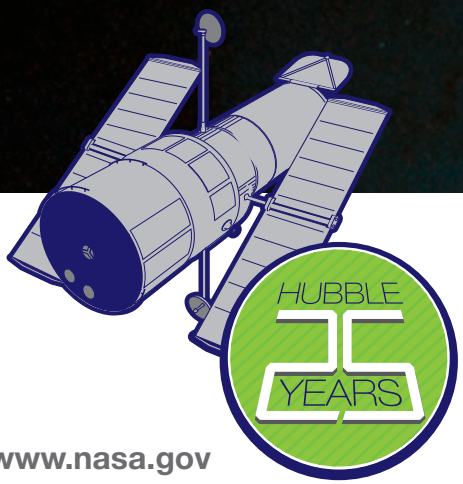
scientific papers, making it one of the most successful scientific instruments ever built

Hubble has the accuracy of .007 arc seconds, which is like being able to shine a laser beam on a dime 200 miles away

Hubble orbits **350 miles** above Earth

Hubble travels around the Earth at 17,500 miles per hour. That's **5 miles per second**

Hubble provides astronomers with an observable universe 250 times larger than viewable from the ground, making the farthest reaches of the universe 13 billion light years away



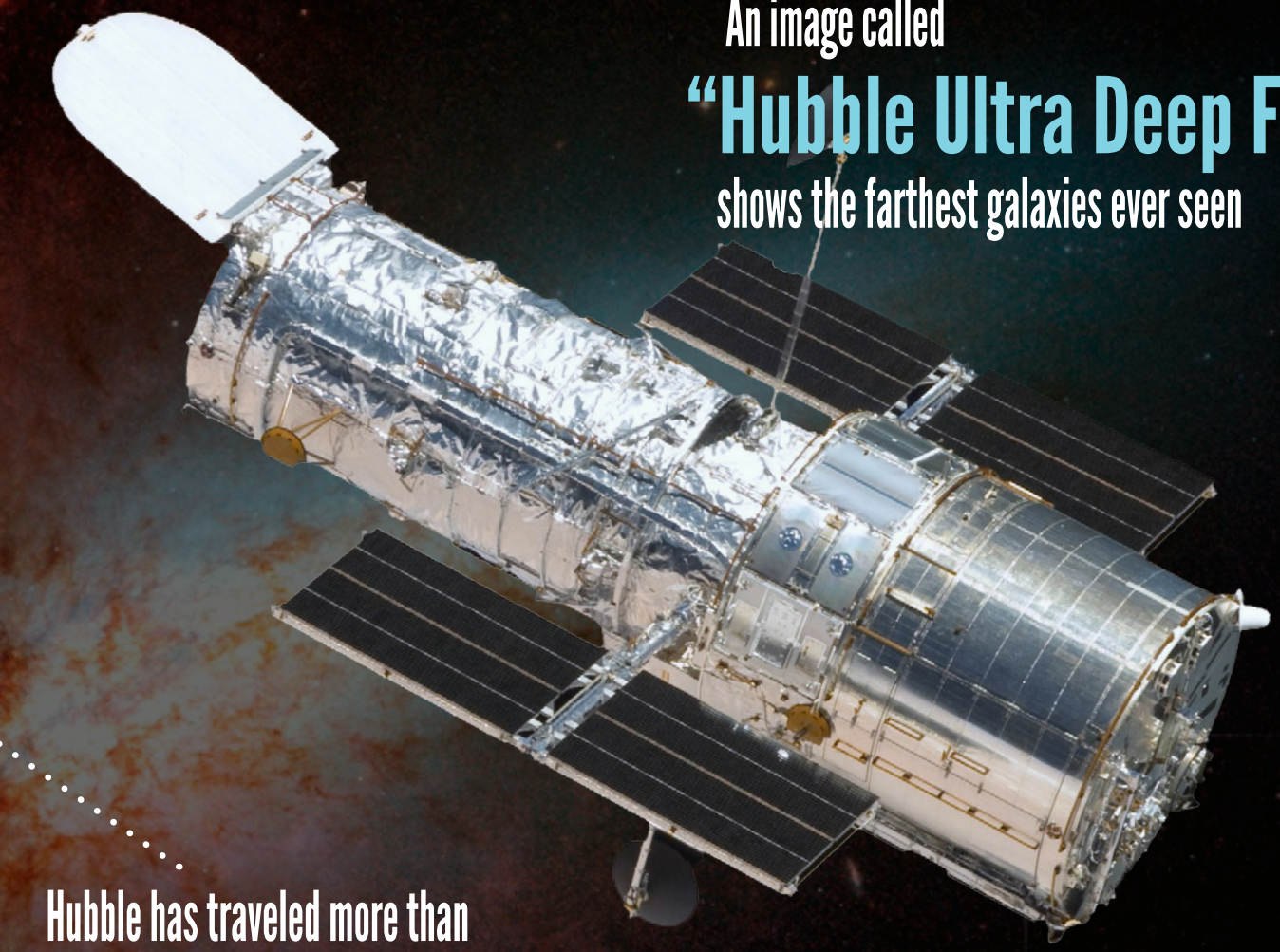
CELEBRATING 25 YEARS O

www.nasa.gov

ASA's Hubble Telescope has made more than

1 MILLION
observations

National Aeronautics and
Space Administration



An image called

"Hubble Ultra Deep Field"

shows the farthest galaxies ever seen

Hubble has traveled more than

3 billion miles

while orbiting around the Earth

Hubble generates about

10 terabytes

of new data per year

F NASA'S HUBBLE SPACE TELESCOPE

HUBBLE SPACE TELESCOPE

SERVICING MISSIONS

Servicing Mission 1 - Restoring Hubble's Vision

Dec. 2-13, 1993

Mission STS-61

Space shuttle Endeavour

Crew: Commander Richard Covey, Pilot Kenneth Bowersox, Payload Commander Story Musgrave, Mission Specialists Kathryn Thornton, Claude Nicollier, Jeffrey Hoffman and Tom Akers.

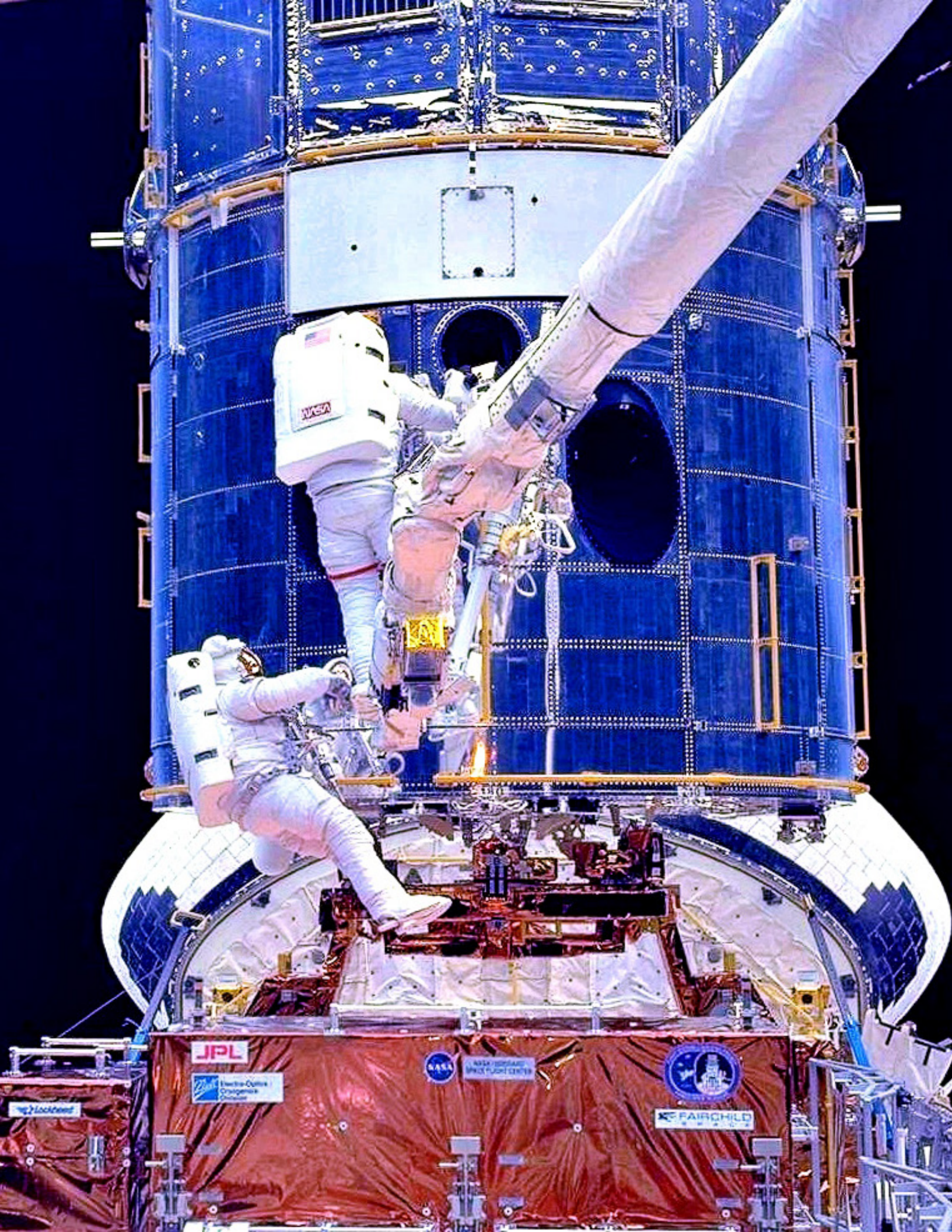
Servicing Mission 1 demonstrated NASA's capability to service an orbiting spacecraft in orbit. The mission's most important objective was to install two devices to fix Hubble's vision problem.

The crew caught up with Hubble in orbit, captured it and placed it in the shuttle's payload bay for a tuneup.

During the nearly 11-day mission, mission specialists installed the Wide Field and Planetary Camera 2 (WFPC2) and the Corrective Optics Space Telescope Axial Replacement (COSTAR) on Hubble. Both were designed to compensate for the primary mirror's incorrect shape.

Also, new solar arrays were installed to reduce the "jitter" caused by excessive flexing of the solar panels during the telescope's orbital transition from cold darkness into warm daylight. New gyroscopes also were added to help point and track the telescope.

NASA astronaut Jeffrey Hoffman, anchored on the end of the Remote Manipulator System arm, prepares to be elevated to the top of the towering Hubble Space Telescope to install corrective optics during Servicing Mission 1. Astronaut Story Musgrave, lower left, assists. Photo credit: NASA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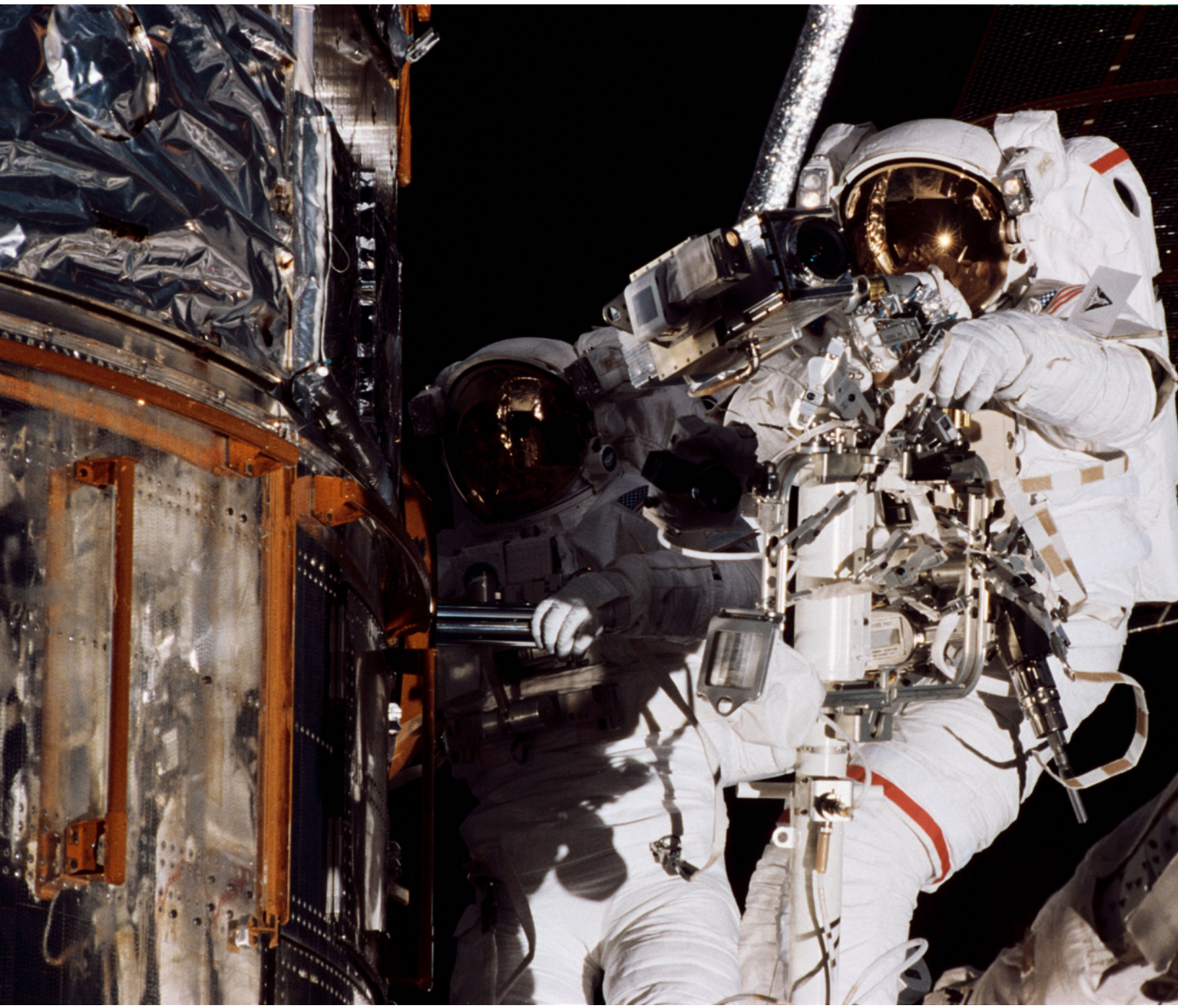


During Servicing Mission 2, NASA astronauts Mark Lee and Steve Smith attached Multilayer Insulation (MLI) patches on the Hubble Space Telescope during flight day 8. Lee is standing on the Remote Manipulator System manipulator foot restraint as he attaches the MLI patches on the telescope. Smith comes up to watch and assist Lee. Photo credit: NASA

Servicing Mission 2 - Expanding Hubble's Universe

Feb. 11-21, 1997

Mission STS-82

Space shuttle Discovery

Crew: Commander Kenneth Bowersox, Pilot Scott Horowitz, Mission Specialists Mark Lee, Steven Hawley, Gregory Harbaugh, Steven Smith and Joseph Tanner.

During the 10-day mission, mission specialists installed two technologically advanced instruments on Hubble. The Near Infrared Camera and Multi-Object Spectrometer (NICMOS) can observe the universe in the infrared wavelengths. The second instrument, the Space Telescope Imaging Spectrograph (STIS), is used to take detailed pictures of celestial objects and to hunt for black holes.

Also installed on Hubble were a refurbished Fine Guidance Sensor, which is used to provide pointing information for the spacecraft to keep it on target and to calculate celestial distances. Hubble also received a new solid state recorder, which replaced an older data recorder

Servicing Mission 3A - Holiday House Call

Dec. 19-27, 1999

Mission STS-103

Space shuttle Discovery

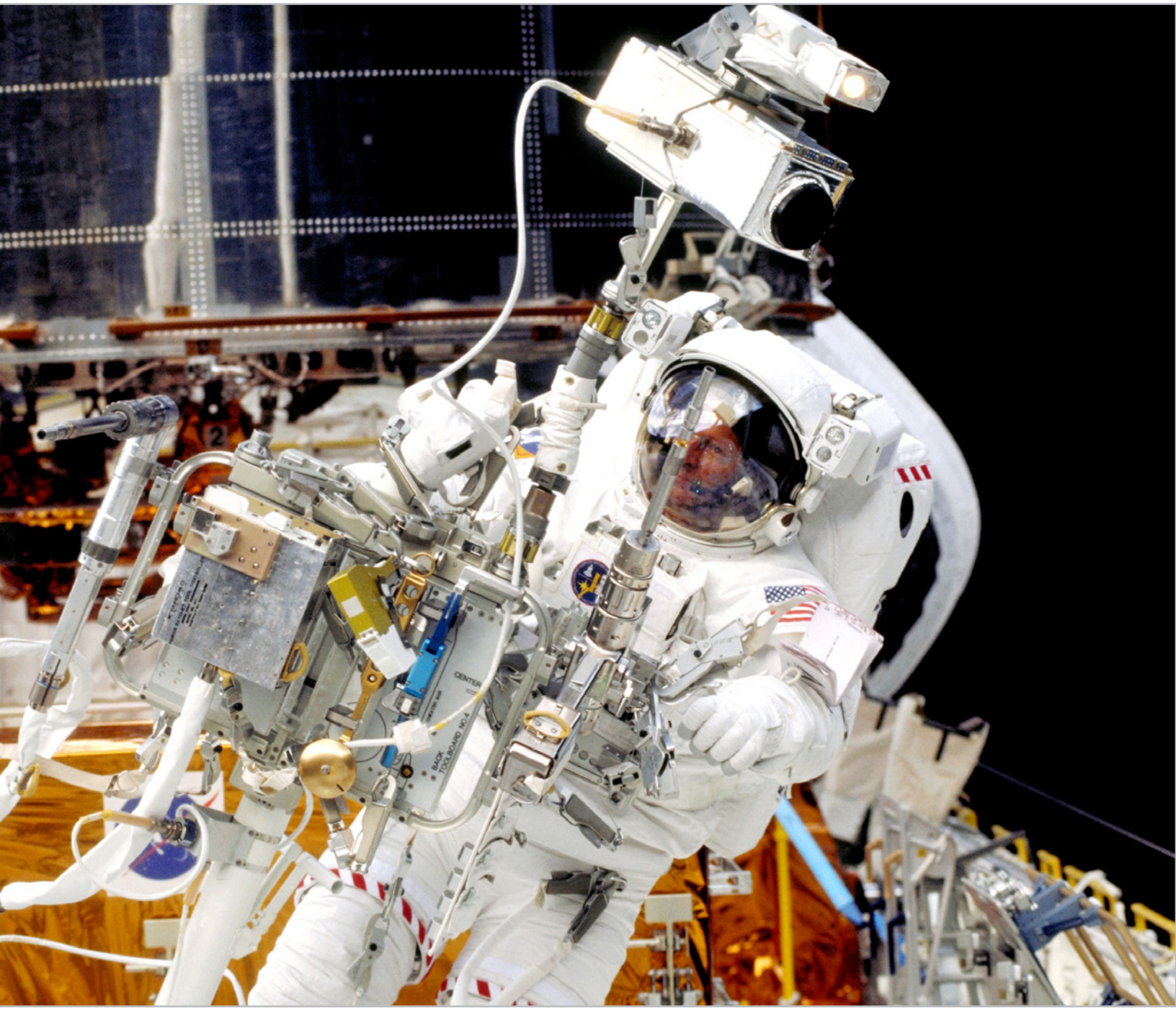
Crew: Commander Curtis Brown, Pilot Scott Kelly, Mission Specialists Steven Smith, Michael Foale, John Grunsfeld, Claude Nicollier and Jean-Francois Clervoy.

Astronauts paid the giant observatory a special holiday visit. The busy mission included replacing all six of Hubble's gyroscopes, which accurately point the telescope at celestial targets. Also, one of three fine guidance sensors, which allows fine pointing and keeps the telescope stable during observations was replaced.

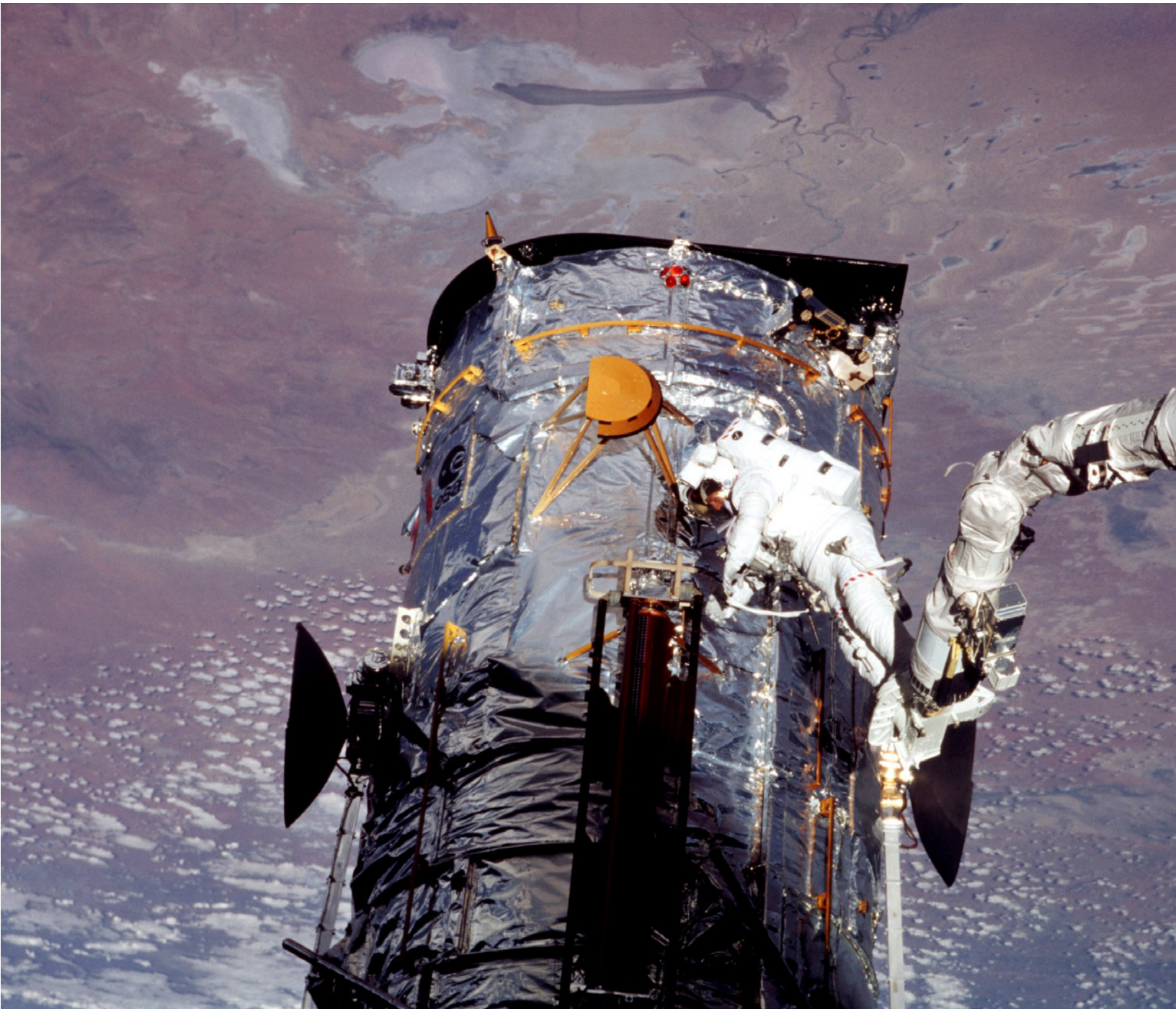
An advanced central computer, a digital data recorder and an electronics enhancement kit also were installed, along with new outer layers of thermal protection.

The crew of Discovery deployed Hubble back into orbit on Christmas Day.

Servicing Mission 3B - Increasing Hubble's View



During Servicing Mission 3, mission specialist Claude Nicollier stands on a portable foot restraint on the end of the Remote Manipulator System (RMS) arm during the second of three extravehicular activities to repair the Hubble Space Telescope. The Orbital Replacement Unit Carrier and part of Hubble is seen in the background. A variety of tools are attached to the RMS work platform. Photo credit: NASA



Perched on the end of shuttle Columbia's remote manipulator system arm, astronaut Michael Massimino removes the old solar array on the port side of the Hubble Space Telescope on March 5, 2002. Astronauts Massimino and James Newman went on to replace the array with a new one. A day earlier, two other astronauts accomplished the same feat on the starboard side. Photo credit: NASA

March 1-12, 2002

Mission STS-109

Space shuttle Columbia

Crew: Commander Scott Altman, Pilot Duane Carey, Payload Commander John Grunsfeld, Mission Specialists Nancy Currie, James Newman, Richard Linnehan and Michael Massimino.

During the 11-day mission, crew members completed the principal task, which was to install a new science instrument called the Advanced Camera for Surveys (ACS). It was the first new instrument installed on Hubble since 1997. ACS enhanced the telescope with its wide field of view, sharp image quality and enhanced sensitivity. It doubled Hubble's field of view and collects data 10 times faster than the earlier surveying instrument, WFPC2.

Astronauts also installed a new cooling system for the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). One of the four reaction wheel assemblies that make up Hubble's pointing control system was replaced to correct steering of the telescope.

Servicing Mission 4 - Final House Call

May 11-24, 2009

Mission STS-125

Space shuttle Discovery

Crew: Commander Scott Altman, Pilot Gregory Johnson, Mission Specialists Megan McArthur, Andrew Fuestel, John Grunsfeld, Michael Massimino and Michael Good.

For the final servicing mission, Discovery carried about 22,000 pounds of hardware onboard, including four carriers containing new science instruments, replacement hardware and tools to upgrade the telescope. The objective was to prepare Hubble for long-term operation and stability with new science-gathering capability.

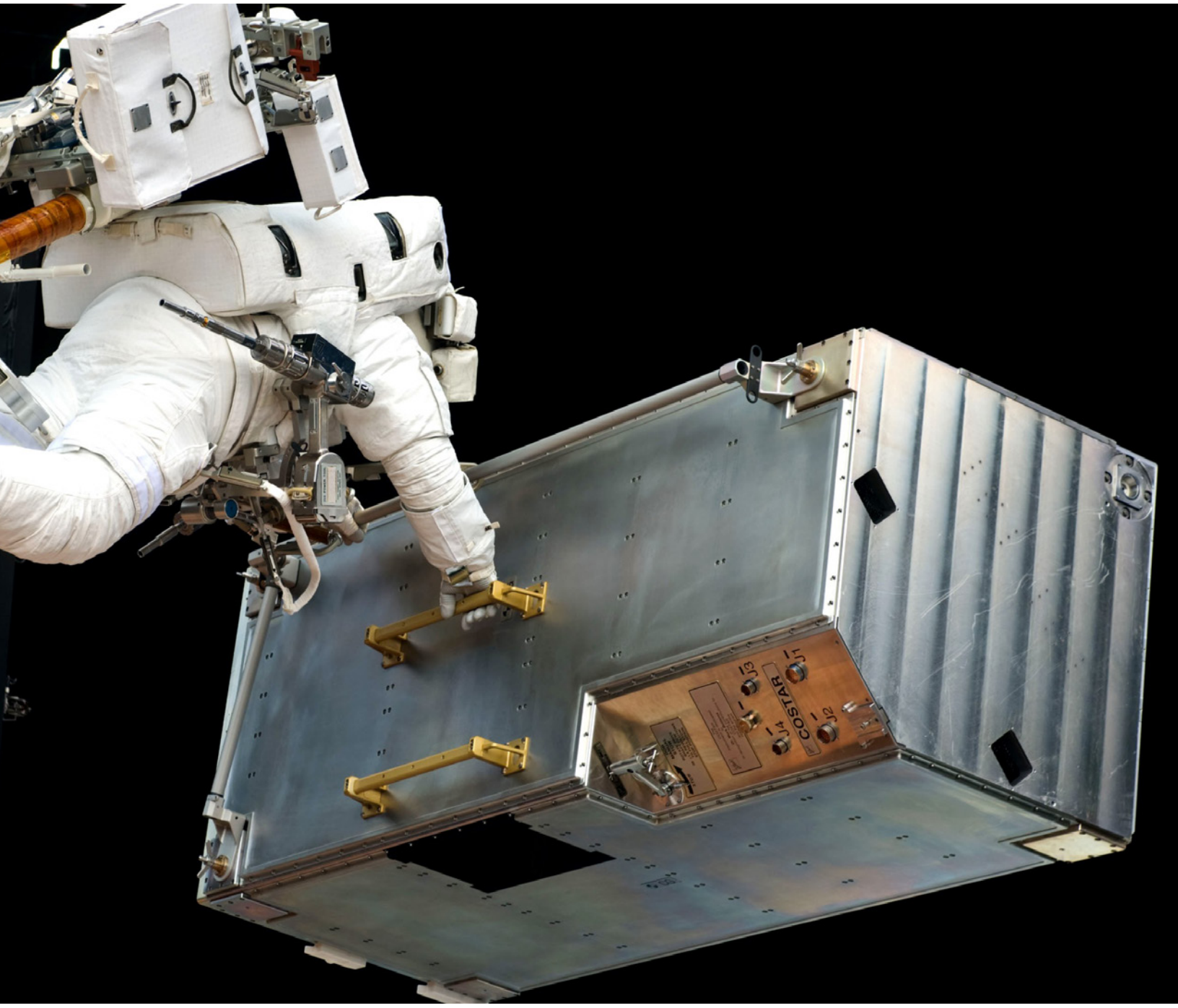
Two new instruments were installed on Hubble: the Wide Field Camera 3 (WFC3) and the Cosmic Origins Spectrograph (COS).

Astronauts removed Hubble's Wide Field and Planetary Camera 2 from the first servicing mission to make room for WFC3. The new camera sees three different kinds of light: near-ultraviolet, visible and near-infrared, though not simultaneously. The camera's resolution and field of vision is much greater than the previous instruments.

COS took the place of a device installed in Hubble during the first servicing mission, the COSTAR. COS is a spectrograph that breaks light into its component colors, revealing information about the object emitting the light. It sees exclusively in ultraviolet light. COS improved Hubble's ultraviolet sensitivity at least 10 times, and up to 70 times when observing extremely faint objects.

The crew also repaired the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS). Both had been installed on Hubble during previous servicing missions.

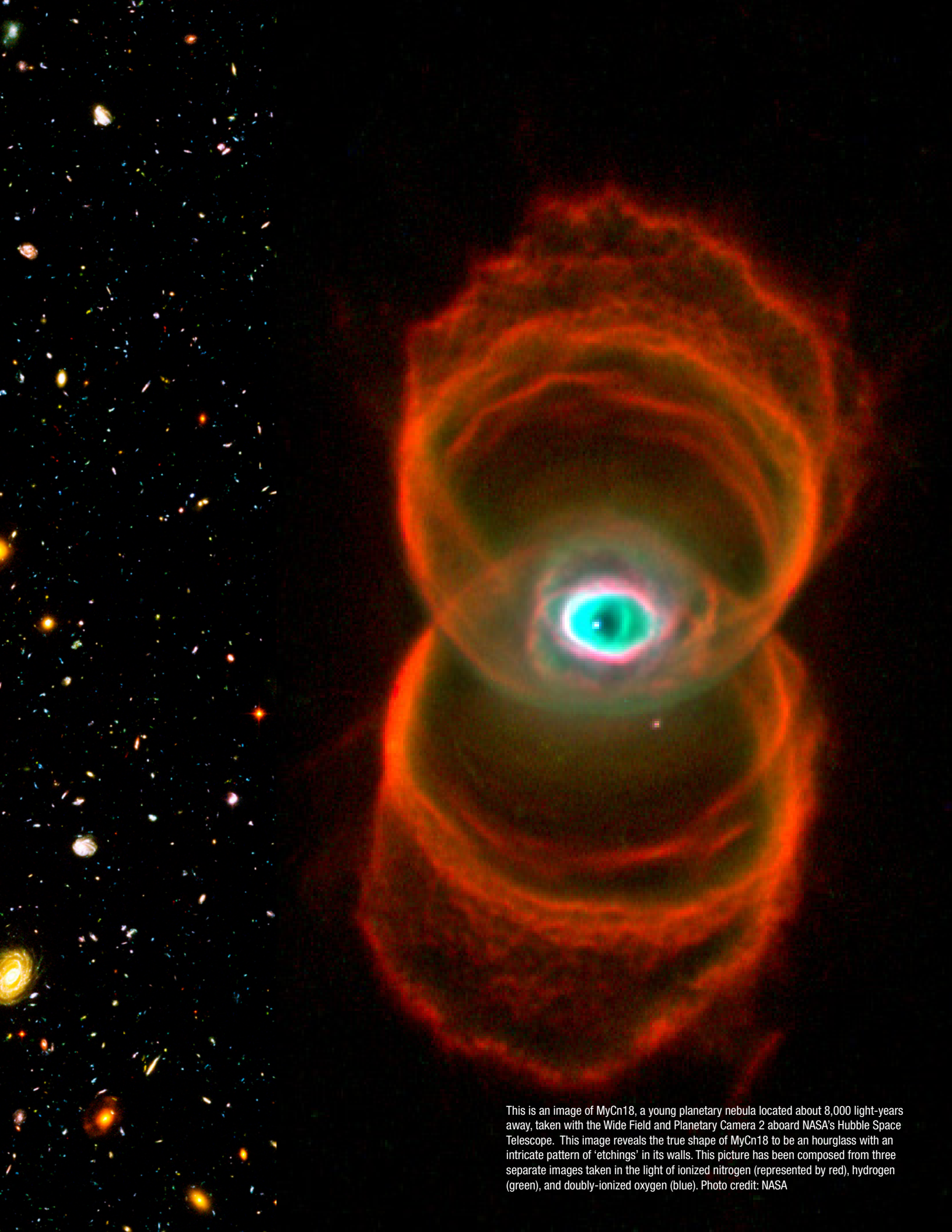
For more information, visit the



Astronaut Andrew Feustel, STS-125 mission specialist, is positioned on a foot restraint on the end of shuttle Atlantis' remote manipulator system May 16, 2009, as he moves the Corrective Optics Space Telescope Axial Replacement (COSTAR) during the mission's third session of extravehicular activity to upgrade and refurbish the Hubble Space Telescope. Photo credit: NASA

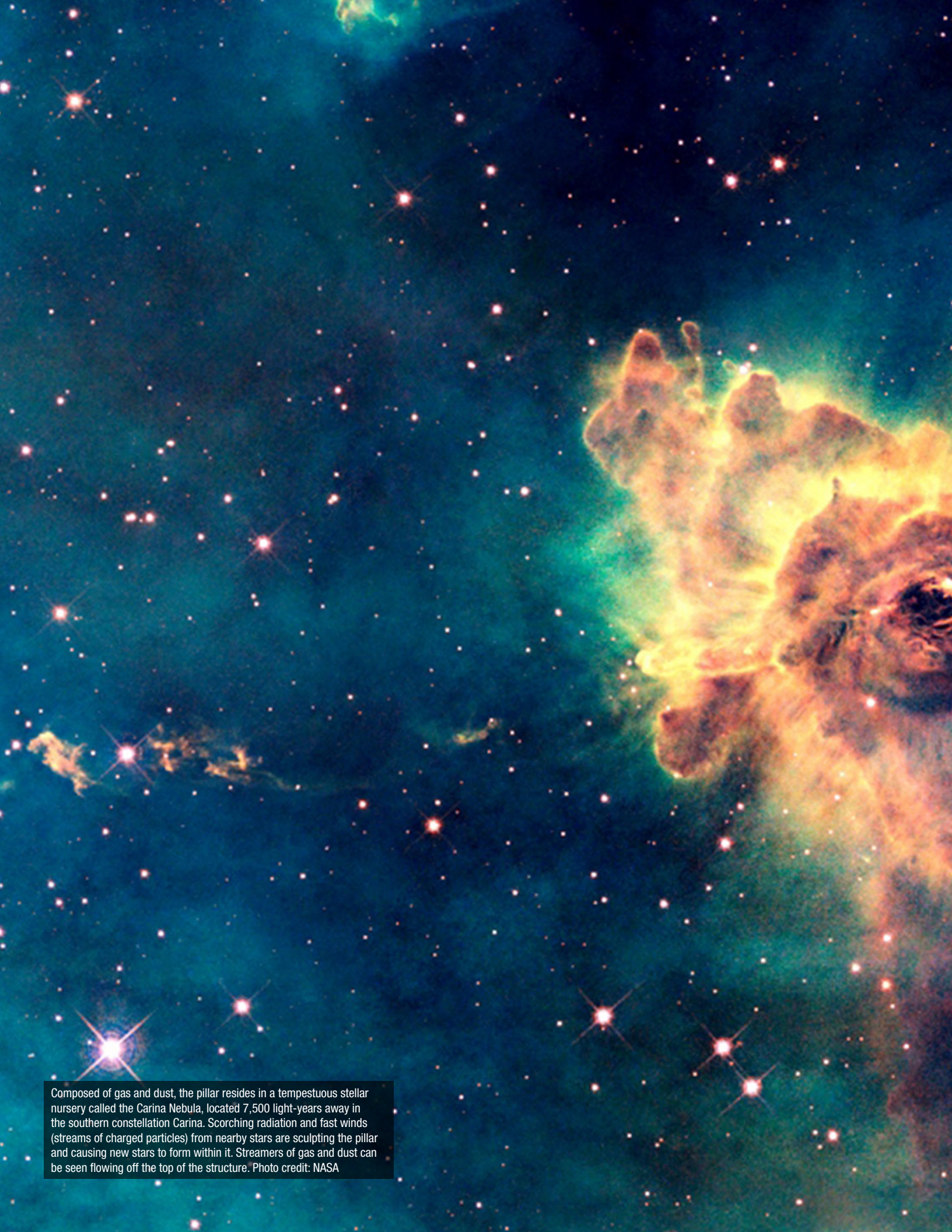
Hubble Space Telescope website at: http://www.nasa.gov/hubble

The Hubble Deep Field surveys will likely be thought of as Hubble's most lasting science legacy. These observations continue to supply a wealth of understanding about the universe as a whole, the evolution of galaxies, and other fundamental information. Of these images the Hubble Ultra Deep Field is a favorite. It produces a strong feeling of depth, almost vertigo, to appreciate that we are looking at nearly the entire sweep of the cosmos filled by a seemingly infinite number of immense galaxies. Photo credit: NASA



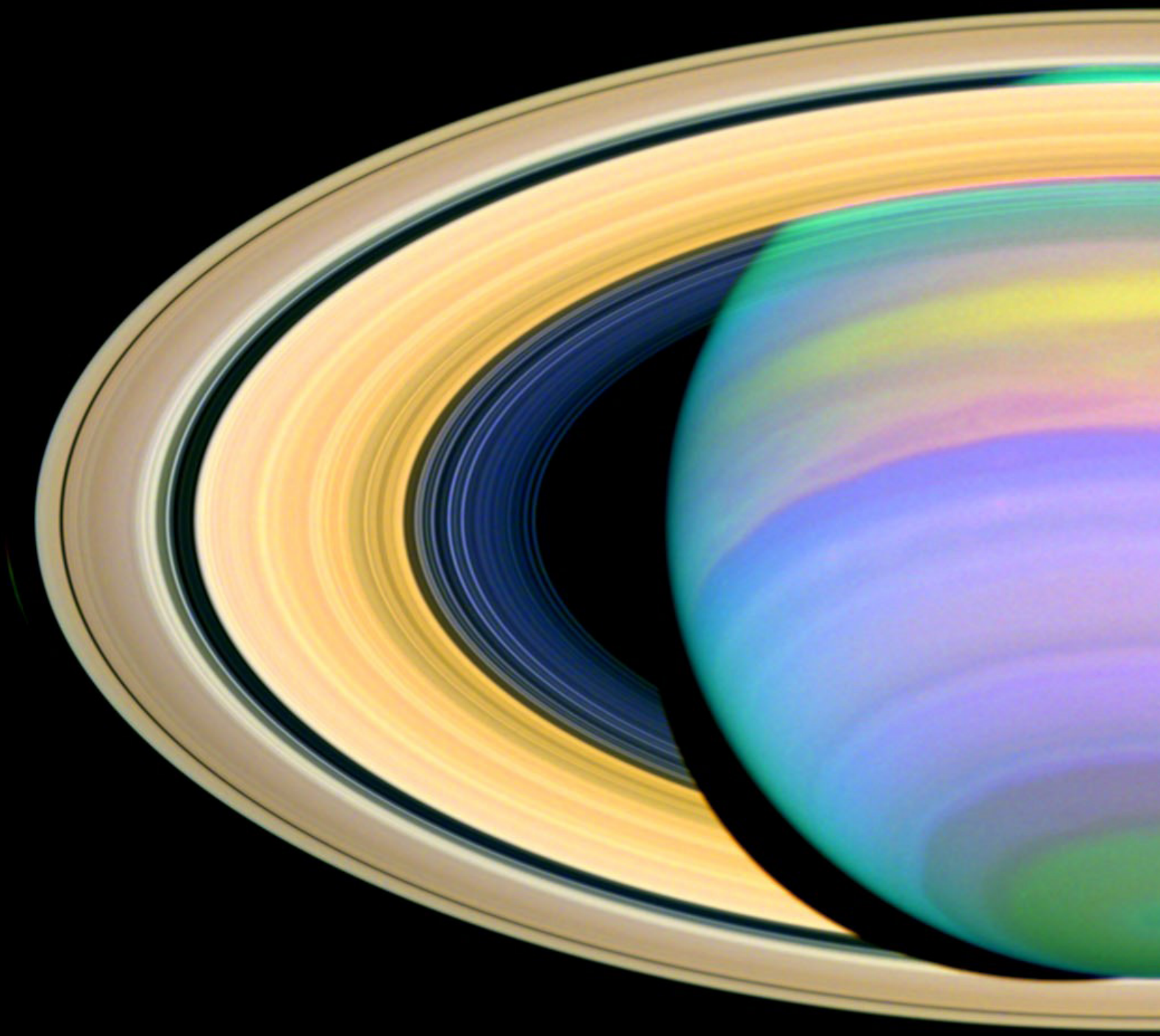
This is an image of MyCn18, a young planetary nebula located about 8,000 light-years away, taken with the Wide Field and Planetary Camera 2 aboard NASA's Hubble Space Telescope. This image reveals the true shape of MyCn18 to be an hourglass with an intricate pattern of 'etchings' in its walls. This picture has been composed from three separate images taken in the light of ionized nitrogen (represented by red), hydrogen (green), and doubly-ionized oxygen (blue). Photo credit: NASA

This spiral galaxy called Sombrero, is seen nearly edge-on. The dark band across the center is the result of material in the flat disk of the galaxy obscuring the light of stars and gas behind it. The glowing bulge holds a population of stars largely different from those in the flat disk. Look close to see numerous globular clusters, which appear as slightly fuzzy stars, each of which is itself composed of many hundreds of thousands of stars. Photo credit: NASA

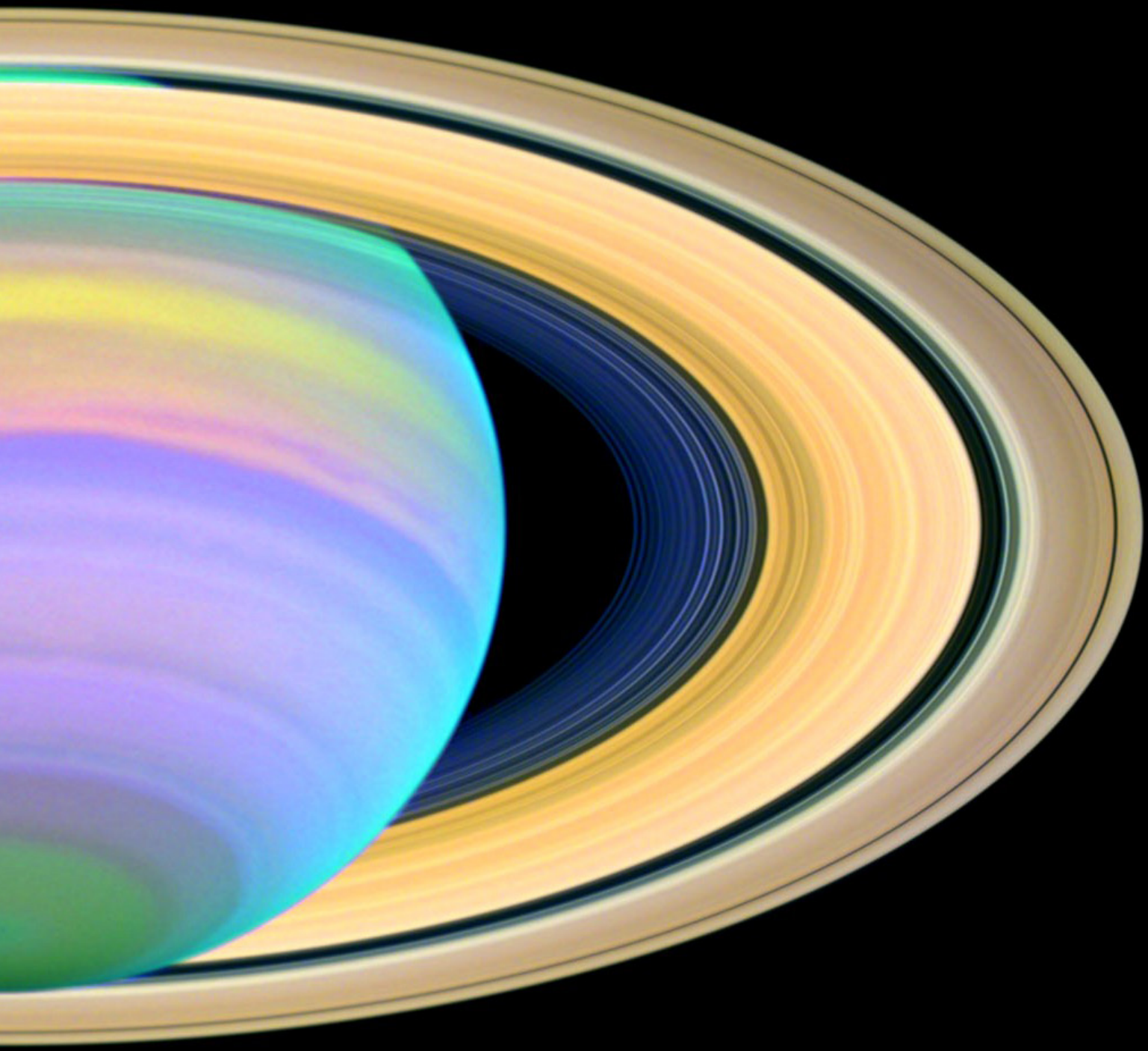


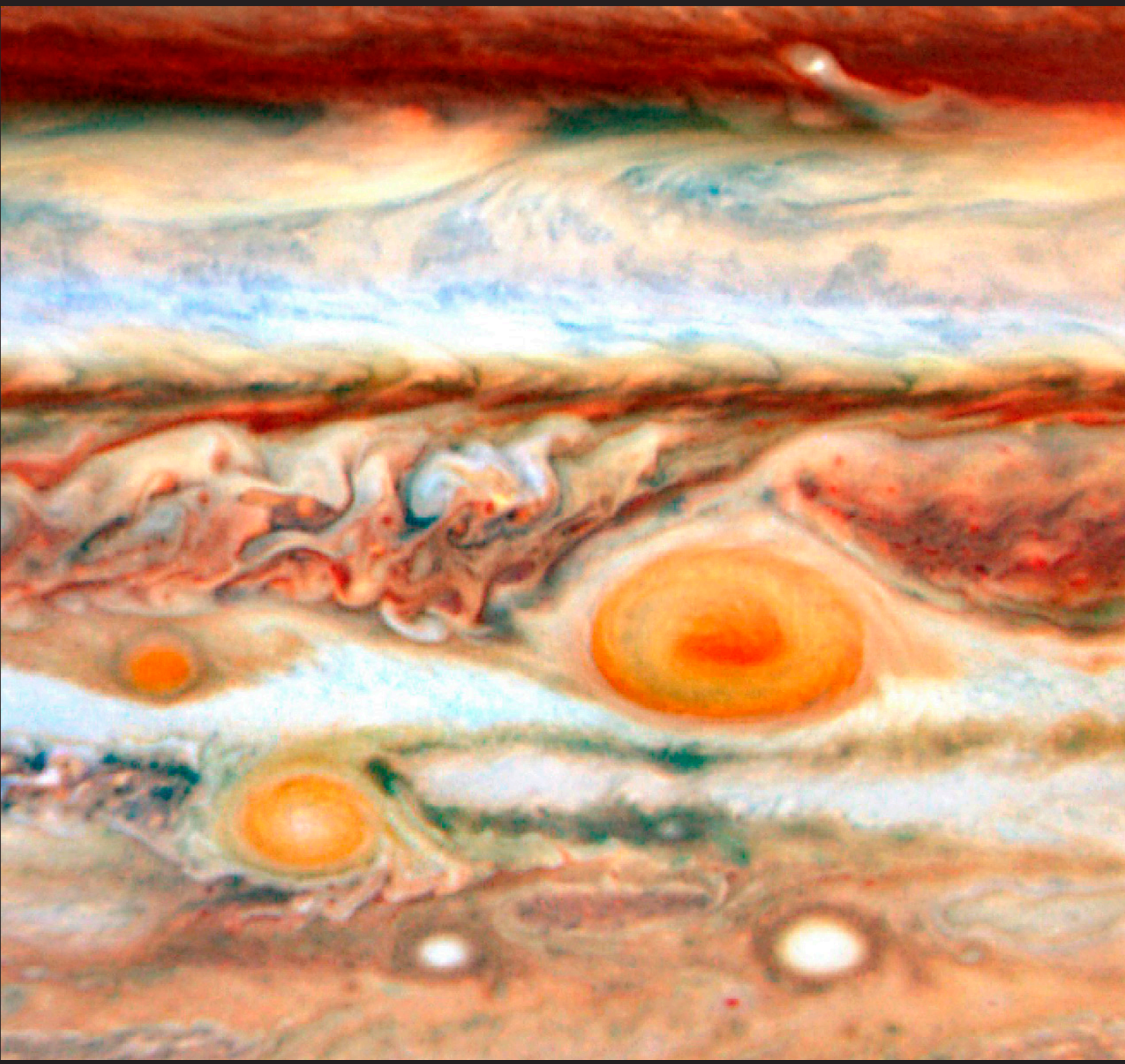
Composed of gas and dust, the pillar resides in a tempestuous stellar nursery called the Carina Nebula, located 7,500 light-years away in the southern constellation Carina. Scorching radiation and fast winds (streams of charged particles) from nearby stars are sculpting the pillar and causing new stars to form within it. Streamers of gas and dust can be seen flowing off the top of the structure. Photo credit: NASA

Astronauts John Grunsfeld (bottom) and Andrew Feustel, perched alone on the end of the space shuttle Atlantis' remote manipulator system, perform the first of five STS-125 spacewalks to perform work on NASA's Hubble Space Telescope, temporarily locked down in the cargo bay of the Earth-orbiting shuttle. The two mission specialists are assigned to two of the remaining four sessions of extravehicular activity. Photo credit: NASA



Saturn is seen here in ultraviolet light. Particles in Saturn's atmosphere reflect different wavelengths of light in discrete ways, causing some bands of gas in the atmosphere to stand out vividly in an image, while other areas will be very dark or dull. This image reveals the properties and sizes of aerosols in Saturn's gaseous makeup. Photo credit: NASA





A third red spot appears alongside its cousins -- the Great Red Spot and Red Spot Jr. -- in the turbulent Jovian atmosphere. This third red spot, which is a fraction of the size of the two other features, lies to the west of the Great Red Spot in the same latitude band of clouds. The new red spot was previously a white oval-shaped storm. The change to a red color indicates its swirling storm clouds are rising to heights like the clouds of the Great Red Spot. Photo credit: NASA

Galaxies collide! The titanic gravitational forces rip apart entire galaxies and they fall back together, forming completely different structures. Interacting galaxies provide some of the most interesting and varied visual forms known. Arp 273 is a particularly interesting example of this, with terrific form, a strong feeling of motion and power, yet extraordinarily graceful. Photo credit: NASA

The starburst galaxy is remarkable for its bright blue disk, webs of shredded clouds, and fiery-looking plumes of glowing hydrogen blasting out of its central regions. Throughout the galaxy's center, young stars are being born 10 times faster than they are inside our entire Milky Way Galaxy. The fierce galactic superwind generated from these stars compresses enough gas to make millions of more stars. Photo credit: NASA

Boeing's Chris Ferguson said the first two Atlas V's to launch the CST-100 will have a parking spot on United Launch Alliance's factory floor in Decatur soon. Photo credit: ULA

COME TOGETHER

Commercial Crew rockets for launches already being built

By Steven Siceloff

The codes AV-073 and AV-080 may not mean much to many, but they mean a whole lot to former astronaut Chris Ferguson and the team of engineers and technicians who will assemble the first Atlas V rocket to launch a crew to the International Space Station. That test and a precursor flight without crew are part of the final development work Boeing is completing with NASA's Commercial Crew Program to certify a new crew transportation system for low-Earth orbit.

On its factory floor in Decatur, Alabama, United Launch Alliance, or ULA, is beginning to fabricate parts for the two rockets that are to launch Boeing's CST-100 spacecraft in 2017.

As Boeing's director of Crew and Mission Systems for the company's commercial crew division, Ferguson toured ULA's assembly factory this week to watch the rockets begin to take shape. Ferguson's last spacecraft, NASA's space shuttle Atlantis, already was built and had achieved veteran spaceflight status years before "Fergie," as he is known, climbed into the commander's seat for the last of the shuttle missions in 2011. Beginning later this year, the CST-100 spacecraft that will launch atop the Atlases will be assembled at another place familiar to Ferguson, a former space shuttle hangar at NASA's Kennedy Space Center.

"The last time we were at this stage of development for a human spacecraft was in the 1970s when we were building the shuttle," Ferguson said. "I have Apollo manuals on my desk -- not to copy designs but to understand how they did it and to validate the decisions we've made with regard to provisions for the crew, what kind of spacesuits they wear, what kind of seats they sit in, and why they sit that way. Engineers put an enormous amount of thought into many low-level designs decades ago, but now we're trying to recreate the "why" behind all that. It's a little intimidating, but it's fun. You

learn why the space program took the shape it is today over five decades ago."

Just like airplanes, rockets have unique tail numbers, or codes, that distinguish them from one another. AV-073 is the 73rd Atlas V that will be built, and AV-080 is the 80th in the line of boosters. Both have another distinguishing characteristic from other Atlas V launch vehicles, as well – since no previous Atlas V has carried people into space, these will be the first to be certified to launch humans. Up until this point, the rockets have been used to lift more than 60 critical missions without people: satellites, robotic probes and even the Mars rovers.

"To have Chris come in and talk to the team really put a face to the program," said Fred Hernandez, production operations chief engineer for ULA. "We're so used to launching things, and so to get to see the people involved in the launching of humans means we're that much closer to our goal."

The factory is building pieces of the rocket unique to the CST-100/Atlas V stack that will be used in the testing regimen. The adapter connecting the top of the rocket's upper stage to the spacecraft, for example, is a new piece that has been meticulously designed and must be built with equal care.

"There are a lot of different major structures for the flight test vehicles that are going through the factory now," Hernandez said.

Manufacturing also has begun for the fuel and oxygen tanks of the Centaur upper stage that will provide the final push to get the CST-100 and its crews into Earth orbit.

"They begin constructing the rocket about 18 months in advance, so it's still a little early, but a lot of the parts that will go into our first vehicle are here," Ferguson said, "so component-level assembly's going on. We don't have a parking spot out here yet, but it comes very soon. And by the end of the year we will have an actual slot. It'll become very, very real when that happens."

NASA's Commercial Crew Program relied on years of human spaceflight experience to develop the requirements needed to ensure transportation systems are qualified to fly astronauts. Through a Commercial Crew Transportation Capability, or CCtCap, contract, NASA will work with Boeing to ensure its rocket, spacecraft and associated ground and mission systems are safe and reliable.

For starters, each Atlas V will carry an extensive suite of sensors and fly with a robust computer that together will be able to detect a problem in the booster as it launches and ascends into space. Although unlikely to occur, a problem severe enough to risk the mission would trigger an abort sequence for the rocket that would automatically eject the spacecraft and carry its astronaut crew back to Earth safely. Additionally, the boosters for the CST-100 flights will use a Centaur upper stage fitted with two RL10 engines, instead of the usual single engine, to provide added performance.

"We fortunately don't see a lot of surprises in manufacturing," Hernandez said. "The Atlas line builds 10 or 11 rockets a year, and that rhythm alone helps to minimize a lot of the issues that we could have."

AV-073 will be outfitted as though it is carrying a crew but will fly the CST-100 without astronauts in an orbital flight test, a significant step on Boeing's path to certification.

AV-080 is the rocket that will carry the first people inside a CST-100 for a flight into space. Still a flight test, the objective is to launch the Atlas V from Space Launch Complex 41 at Cape Canaveral Air Force Station and place the CST-100 on a path to the station. Crew members will fly to the orbiting laboratory and stay there for a few days while the spacecraft's systems are evaluated for their performance. The flight test crew would then use the vehicle to return home to the United States, completing the test.

An artist rendering of Boeing's CST-100 spacecraft on the launch pad with the Commercial Crew Access Tower. Image credit: United Launch Alliance

Although still about two years away, the flight tests are close enough to prompt excitement and ramp up anticipation almost daily at the Atlas V assembly hall.

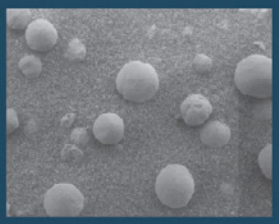
"We're obviously very proud of our success rate, and we're sort of taking the approach that we have a recipe for mission success, and we have to continue to execute on that," Hernandez said. "If we keep that focus, that will transition over into the crew vehicles as well."

OPPORTUNITY'S **MARATHON** JOURNEY!

First Marathon "Run" on Another Planet

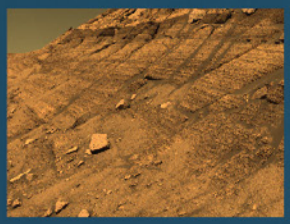
Distance: 26.2 miles **Time:** 11 years, 2 months

A GREAT START



At landing, Opportunity finds signs of acidic water in Mars' ancient past.

LONG WAY TO GO



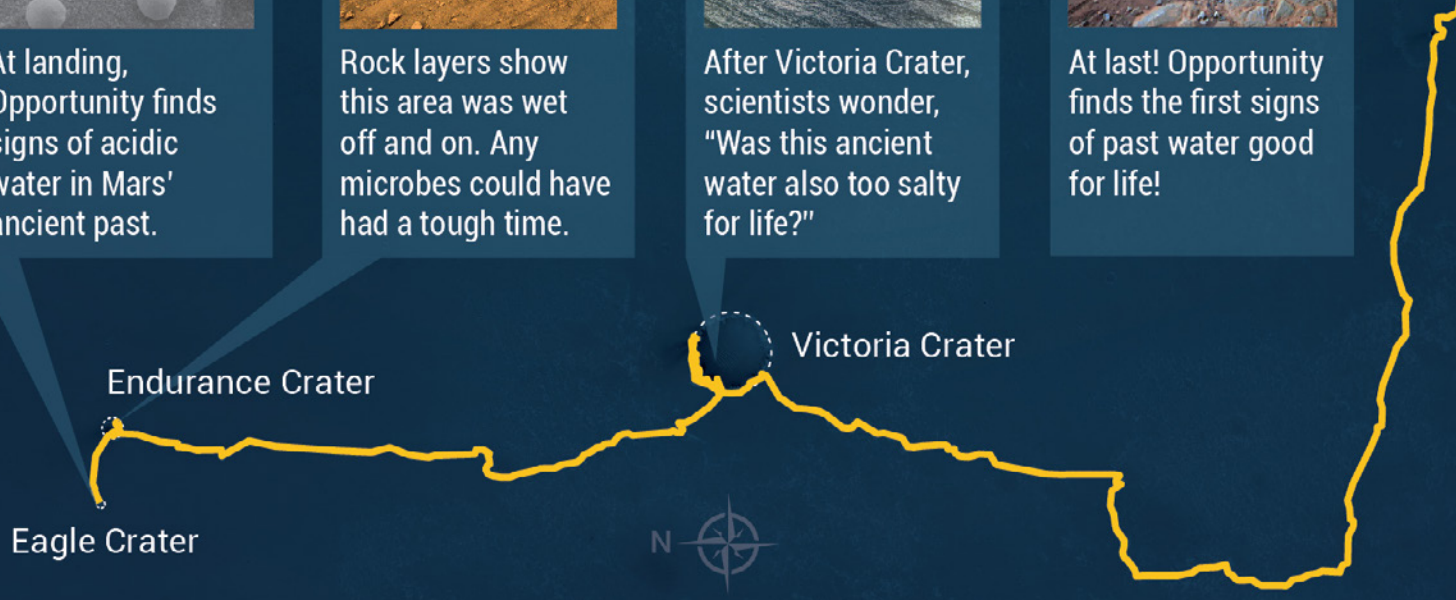
Rock layers show this area was wet off and on. Any microbes could have had a tough time.

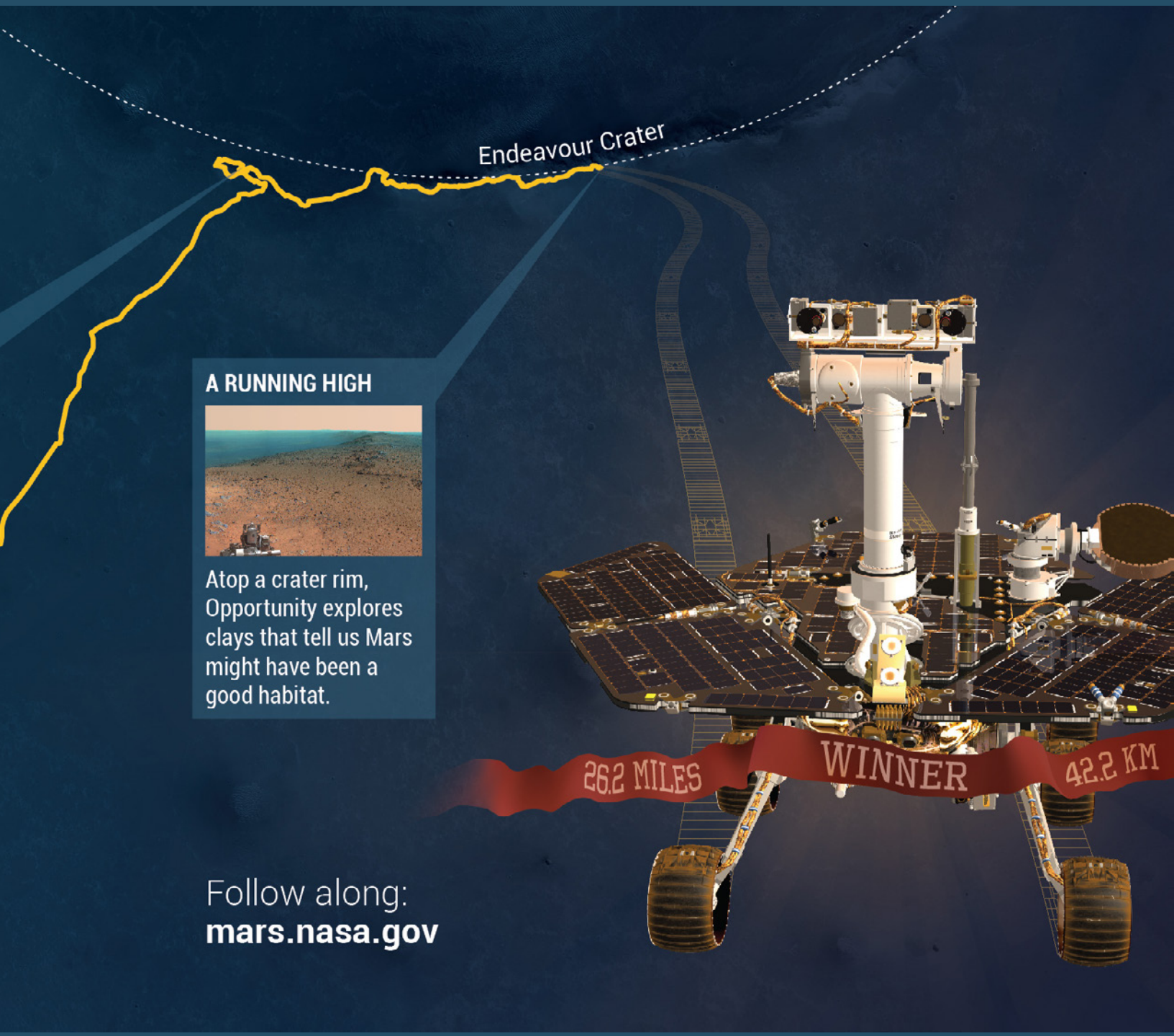
TOUGH CHALLENGE

After Victoria Crater, scientists wonder, "Was this ancient water also too salty for life?"

GETTING IN STRIDE

At last! Opportunity finds the first signs of past water good for life!




Endeavour Crater
A RUNNING HIGH
Atop a crater rim, Opportunity explores clays that tell us Mars might have been a good habitat.
26.2 MILES
WINNER
42.2 KM
Follow along:
mars.nasa.gov

STUDY TIME

Students from the University of Texas at El Paso examine debris pieces from space shuttle Columbia. From the left are Jessica Buckner, Ilse Alcantara and Brenda Arellano
Photo credit: University of Texas-El Paso

Students applying lessons learned to develop safer spacecraft

By Bob Granath

Students from the University of Texas at El Paso (UTEP) are collaborating with NASA engineers at the Kennedy Space Center in an effort to use lessons learned from the past to design safer spacecraft for the future.

The graduate and undergraduate researchers are part of UTEP's Center for the Advancement of Space Safety and Mission Assurance Research (CASSMAR). The multidisciplinary research group has focused on risk-reduction research to make spaceflight reliable and successful.

Former NASA astronaut and UTEP alumnus John "Danny" Olivas, Ph.D., is now the university's director of space initiatives and also leads CASSMAR.

According to Olivas, development of spacecraft such as Orion, those that are a part of the Commercial Crew Program and vehicles now on the drawing board, provide opportunities for fresh ideas on design with a focus on crew safety.

"The United States is at the dawn of a new era of space exploration, so I am thrilled about this development," said Olivas, who earned his bachelor's degree in mechanical engineering from UTEP in 1989. "The University has the right people and the right facilities and capabilities to do this work."

Olivas was awarded his doctorate in mechanical engineering and materials science from Rice University in 1996. He flew on two space shuttle missions, STS-117 in June 2007 and STS-128 in August and September 2009.

Throughout its history, NASA has continued efforts to make crew safety a paramount focus incorporating experiences from the past. This is especially true in developing Onion and the agency's work with its industry partners in designing spacecraft for the Commercial Crew Program (CCP).

NASA's Orion spacecraft is designed to expand human presence in deep space and enable exploration of new destinations in the solar system. It will take crews farther than they've ever gone before, enabling missions to asteroids and, eventually, to Mars.

Under CCP, Boeing and SpaceX are developing spacecraft to transport astronauts to the International Space Station from U.S. soil.

Last summer, the UTEP students traveled to Kennedy to work with engineers at the Florida spaceport.

"We had the opportunity to host the group from the University of Texas at El Paso," said Clara Wright, a NASA materials engineer in Kennedy's Engineering and Technology Directorate. "They are examining debris from the space shuttle Columbia in order to learn about material behavior during re-entry in hopes of making more reliable vehicle designs. It is a continuation of the Johnson Space Center-led Columbia Crew Survival Investigation that we at Kennedy supported."

During their visit to Kennedy last August, the UTEP students met with NASA engineers such as Wright, toured materials engineering laboratories, saw the Orion spacecraft being prepared for its flight in December, and examined the space shuttle Atlantis.

As part of UTEP's new research focus, NASA's Columbia Research and Preservation Office at Kennedy has loaned the university several debris pieces from the shuttle that was lost along with its crew in 2003. Faculty and students will initially focus on previously unstudied materials-behavior issues that have been observed in the specimens.

Late last year, Matt Garcia earned a bachelor's degree in metallurgical and materials engineering at UTEP. Now a graduate student, he believes much can be learned from studying pieces of the debris.

"Each piece has a story to tell," Garcia said. "Different materials responded to the stresses of spaceflight in a different manner. We want to understand what provides the greatest strength against the unyielding forces of spaceflight and what materials provide the most robust capabilities for spaceships of the future."

Ngozi Ochoa is working on a doctorate in the Material Science and Engineering Department at UTEP. Her research includes performing studies of the titanium, nickel and aluminum alloys in Columbia components to better understand material behavior during re-entry.

"We were able to identify surface compositions using X-ray fluorescence," she said. "While no conclusions have yet been drawn, we determined areas of interest."

"Each of the shuttle Columbia pieces we have contain significant and unstudied characteristics of the entry environment which will demonstrate the need for deeper investigation and understanding," Olivas said. "Some of the very same materials are being used in the aerospace industry today. Engineers are designing spacecraft with limited knowledge of how these materials react in the re-entry environment. Our goal is to perform the necessary research to broaden knowledge for the entire spacefaring community."

Brenda Arellano, a UTEP graduate research assistant who also is pursuing a Ph.D. in materials science and engineering, says there were some surprises in their findings.

"For the most part our visual inspection focused on how different the material held up," she said, "but we didn't expect the extent of texturing and depositions on the materials caused by re-entry burns. Our future studies may need to focus on improvements in commonly used spacecraft materials such as titanium alloys in order to create a stronger spacecraft structure."

Arellano says she hopes their research and the efforts of others lead to a better understanding of how various material withstand the extreme forces experienced in travel beyond Earth.

Experts at Kennedy are already working on better metal alloys. Wright is the principal investigator in a project called "SMASH," for Shape Memory Alloy Self-Healing, a technology that creates metals that, when damaged, can repair themselves.

The graduate and undergraduate researchers are part of University of Texas at El Paso's Center for the Advancement of Space Safety and Mission Assurance Research (CASSMAR) organization From the left are Matt Garcia, Mayra Contreras, Mayela Aldaz-Cervantes, Brenda Arellano, Jessica Buckner, Ngozi Ochoa and Ilse Alcantara. The multidisciplinary research group has focused on risk-reduction research to make spaceflight reliable and successful. Photo credit: University of Texas-El Paso

According to Garcia, making flight safety a paramount concern will always be the key to avoiding problems in flight.

"No matter how much effort we put into designing better spacecraft, there will always be risk," he said. "Against the stresses of launch, flying beyond Earth and entering the atmosphere, the best vehicles can still be fragile. While we want to make sure we build the strongest, best spacecraft possible, attention to detail will always be crucial."

"The UTEP CASSMAR group is going to be conducting the research for a few years so I think that it's always a good story," said Wright, "especially because they're trying to use lessons learned from the Columbia accident as a way to make future spacecraft safer."

Ochoa noted that she appreciates the experience working with engineers at Kennedy and the opportunity to study the Columbia debris.

"We are excited to be able to share our findings, hopefully making an impact, even if small, on future spaceflight developments," she said.

Olivas believes the legacy of Columbia is really about learning.

"Researchers investigating her will learn what we can do to be safer in the future so that accidents like this do not happen again," he said. "Students are going to have a unique opportunity to be a part of the leading edge of space exploration. These future space pioneers will be doing research in new fields that have never been fully explored for applicability to space environments."

As executive director of CASSMAR at UTEP, Darren Cone also is pleased with the experience his students are receiving by collaborating with engineers at Kennedy.

"I'm really glad this effort is getting some attention, as we feel it is highly relevant to our country's future in manned spaceflight," he said.

"Spaceflight is a collaborative solution," Olivas said. "As an astronaut, you don't get to space on your own; you stand on the shoulders of giants who put you there."

GIRL POWER

Role in space travel highlights Women's History Month

Employees listen as Women's History Month panelists share their experiences. Photo credit: Tony Gray

By Kay Grinter

NASA's Kennedy Space Center celebrated Women's History Month by inviting employees to hear a panel of leaders and directors from NASA's past and present -- all accomplished women -- discuss the stories of their lives and careers with the agency.

George Jacobs, deputy director of Center Operations, was Master of Ceremonies for the event held March 26 in the Kennedy Learning Institute. NASA is "no longer a 'good ole boys' network," he observed as he introduced the distinguished panel.

Providing their insights were Kennedy directors Josie Burnett of the International Space Station Ground Processing and Research Project Office, Nancy Bray of Center Operations, and Digna Carballosa of Human Resources. Also participating was Rita Willcoxon, former director of Launch Vehicle Processing, now retired from NASA and employed by General Electric Transportation in Melbourne, Florida.

Gordy Degear, program analyst in the Office of the Center Director and facilitator for the program, opened the discussion by asking the panelists what brings them happiness. All agreed that family fulfilled them and made their time away from home worthwhile.

Burnett recalled a time when her three-year-old grandson recognized her in a photo posted online, in which she was shaking hands with NASA's Robonaut before it was flown to the International Space Station. He was delighted. "It made me proud that he's proud of the work I do," she said.

Degear next asked the panelists to describe the changes they had witnessed during their careers.

Willcoxon recalled that Joann Morgan and Ann Montgomery were the only women in technical management positions when she started working at the center. Morgan, an engineer, was the only woman during the Apollo launches who supported the countdowns from the firing room; Montgomery was the first woman assigned as a flow director for a space shuttle, the orbiter Columbia.

At the moment, Kennedy's Executive Team is made up of ten men and nine women, including Kennedy's Deputy Director Janet Petro and Chief Financial Officer Susan Kroskey. After commenting that three of Kennedy's four primary programs and projects are led by women, Bray got a positive response from the largely female audience when she observed "women are taking us into outer space."

How can we keep this trend growing? By encouraging girls to study the STEM disciplines in school -- science, technology, engineering and mathematics -- the components of NASA's education initiative, all agreed. Students generally decide "by the fifth grade whether to go into STEM fields," Carballosa commented.

The percentage of "girls going into engineering hasn't changed in 15 years," Willcoxon said. We should "look for ways to inspire girls to go into engineering," she suggested. Burnett concurred and raised the question educators ponder of whether engineers are "born or derived."

Degear asked the panelists if, in looking back over their careers, there was anything they would do differently.

Bray said that she learned it is important to give employees ample career-development opportunities and found IDPs helpful, bringing a playful groan from the audience. The IDP, or individual development plan, is a tool NASA uses to clarify an individual's long-term career goals. While requiring upfront thoughtful introspection, the plan is valuable in identifying an employee's future steps on her career path.

Carballosa got a chuckle from the audience when she suggested that she would "learn to delegate earlier." Women have a tendency to do everything themselves, she explained, and in doing so may deprive their employees of valuable learning experiences. She encouraged everyone to strive to remain relevant to the organization.

"Staying relevant is a personal commitment one makes in whatever role we happen to be in," Carballosa said. "If you need help linking your job to the mission, challenge your supervisor to help you make this connection."

The event was planned and implemented by members of Kennedy's Federal Women's Program (FWP). The purpose of FWP is to provide focus on issues affecting female employees, such as employment, retention, promotion, training, career development and advancement opportunities. Membership is open to everyone at Kennedy, including both civil service and contractor employees.

KSC Scenes

MMS LAUNCH
A United Launch Alliance Atlas V rocket with NASA's Magnetospheric Multiscale (MMS) spacecraft onboard launches from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida on March 13. The Atlas V rocket carried four identical MMS spacecraft into orbit to provide the first three-dimensional view of magnetic reconnection.

Photo credit:
NASA/Aubrey Gemignani

Images of the Month

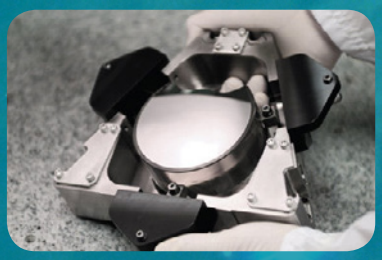
ASTRONAUT SPACESUIT TESTING FOR ORION SPACECRAFT
Engineers and technicians at NASA's Johnson Space Center in Houston are testing the spacesuit astronauts will wear in the agency's Orion spacecraft on trips to deep space. On March 17, members of the Johnson team participated in a Vacuum Pressure Integrated Suit Test to verify enhancements to the suit will meet test and design standards for the Orion spacecraft. During this test, the suit is connected to life support systems and then air is removed from Johnson's 11-foot thermal vacuum chamber to evaluate the performance of the suits in conditions similar to a spacecraft. The suit, known as the Modified Advanced Crew Escape Suit, is a closed-loop version of the launch and entry suits worn by space shuttle astronauts. The suit will contain all the necessary functions to support life and is being designed to enable spacewalks and sustain the crew in the unlikely event the spacecraft loses pressure.
This is the first in a series of four tests with people in the suits to evaluate the performance of the spacesuit systems in an environment similar to a spacecraft.

Learn more about where the suits are tested or track all of the latest news at www.nasa.gov/orion.

Photo credit: NASA/Bill Stafford

HUBBLE SPINOFFS

Since its launch in 1990, NASA's Hubble Space Telescope has transformed our understanding of the universe with its clear, deep, and stunning images. Here are a few spinoffs from the orbiting eye in the sky.



Mirror technology increases semiconductor productivity, performance

The semiconductor industry has benefited from the ultra-precise mirror technology that gives the HST its full optical vision and telescopic power. This technological contribution helped improve optics manufacturing in microlithography -- a method for printing tiny circuitry, such as in computer chips.

Optics tool sharpens record-breaking ice skates

Olympic record-holding speed skater Chris Witty raced her way to a gold medal in the 1,000-meter at the 2002 Salt Lake City Winter Olympics. Witty and other American short- and long-track speed skaters used a blade-sharpening tool designed with the help of NASA Goddard Space Flight Center and technology from HST.

CCDs enable clearer, more efficient biopsies

Charge coupled devices (CCDs) used on the HST to convert light into electronic files-- such as a distant star's light directly into digital images -- have been applied to many of the NASA-driven enhancements to the manufacture of CCDs for digital mammography biopsy techniques, using CCDs to image breast tissue more clearly and efficiently. This allows doctors to analyze the tissue by stereotactic biopsy, which requires a needle rather than surgery. Image credit: CSii and MDA

Micro-endoscope refines medical diagnosis

In 2004, the cutting-edge technology that enhances Hubble's images began helping physicians perform micro-invasive arthroscopic surgery with more accurate diagnoses with a tool that enables surgeons to view what is happening inside the body on a screen, eliminating the need for a more invasive diagnostic procedure that could add time, money, and discomfort to a patient's treatment.

Hubble software powers terrestrial observatories

With the help of a software suite created by a NASA industry partner in 1995, students and astronomers were able to operate a telescope at the Mount Wilson Observatory Institute via the Internet. The software is still widely in use for various astronomy applications; using the CCD technology, the software locates, identifies and acquires images of deep sky objects, allowing a user to control computer-driven telescopes and CCD cameras.

For more information about NASA spinoffs, visit spinoff.nasa.gov

National Aeronautics and Space Administration

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