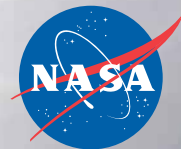


National Aeronautics and  
Space Administration



# 2019 KENNEDY SPACE CENTER Annual Report



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*A SpaceX Falcon 9 rocket carrying a Dragon spacecraft lifts off from Space Launch Complex 40 on Cape Canaveral Air Force Station on May 4, 2019, on the company's 17th cargo resupply mission to the International Space Station.*



# Vision, Mission and Core Competencies



## KSC Vision

KSC is the world's preeminent launch complex for government and commercial space access, enabling the world to explore and work in space.

## KSC Mission

KSC safely manages, develops, integrates and sustains space systems through partnerships that enable innovative, diverse access to space and inspire the nation's future explorers.

## KSC Core Competencies

Acquisition and management of launch services and commercial crew development

Launch vehicle and spacecraft processing, launch, landing, recovery, operations and sustaining

Payload and flight science experiment processing, integration and testing

Designing, developing, operating and sustaining flight and ground systems and supporting infrastructure

Development, test and demonstration of advanced flight systems and transformational technologies to advance exploration and space systems

# Director's Message

Looking back, this has been an exciting year for the team here at NASA's Kennedy Space Center. The continued partnerships we have with our commercial partners have truly transformed Kennedy into the premier, multi-user spaceport it is today.

With more than 90 private-sector partners and 270 partnership agreements, the presence of commercial companies is larger than ever before, enabling us to embark on a new era of space exploration. For the first time ever, the Vehicle Assembly Building will have its first commercial tenant as Northrop Grumman begins to use High Bay 2 to assemble and test its new Omega rocket, further expanding our role in supporting both government and commercial space operations.

We also had the first launch in eight years of a spacecraft designed to carry humans to the International Space Station from Kennedy. The success of SpaceX's Demo-1 mission under NASA's Commercial Crew Program validated the Crew Dragon spacecraft and its systems. We still have a lot of work ahead of us to fully certify these vehicles prior to launching crew, but this is a huge step in the right direction to enable us to launch U.S. astronauts on a U.S. vehicle from U.S. soil once again.

NASA's Launch Services Program supported a total of 21 launches – comprising government and commercial missions – and was awarded management services for three upcoming important launches in 2021. Lucy will be the agency's first-ever mission to explore Trojan asteroids while the DART mission will be the first of its kind to demonstrate deflecting an asteroid by colliding a spacecraft with it at high speed. Lastly, the IXPE mission will measure the polarization of cosmic x-rays.

The mobile launcher made its roll to Launch Complex 39B this summer for final verification and validation testing. At the pad, NASA's Exploration Ground Systems oversaw a series of tests to verify the pad's water deluge system as we prepare for that first launch of the Space Launch System (SLS). Once complete, the next time the mobile launcher rolls out will be with the SLS rocket and Orion on it for the Artemis I mission, an integrated flight test that's a crucial milestone as we get ready to send the next man and first woman to the lunar surface.

This summer also marked the 50th anniversary of that historic Apollo 11 launch that landed the first two humans on the Moon. To commemorate this momentous occasion, Vice President Mike Pence visited Kennedy and unveiled NASA's Orion crew capsule – now complete and ready for environmental testing before launching on Artemis I. The twin sister of Apollo, Artemis will build upon the foundation established by the Apollo Program and ultimately lead us farther than we've ever gone before.

We have a tremendous challenge ahead of us as we charge ahead to the Moon and beyond to Mars, but I'm proud of each and every member of our workforce and everything we've accomplished

thus far. The role that Kennedy plays in our nation's continued spirit of exploration is paramount, and I invite you to review some of our most notable achievements during Fiscal Year 2019 in the following pages.



**Director**  
**ROBERT D. CABANA**



# Top 30 Significant Events



**OCT 2018**  
Astronaut Serena Auñón-Chancellor planted kale and lettuce inside the International Space Station's Veggie plant growth system.



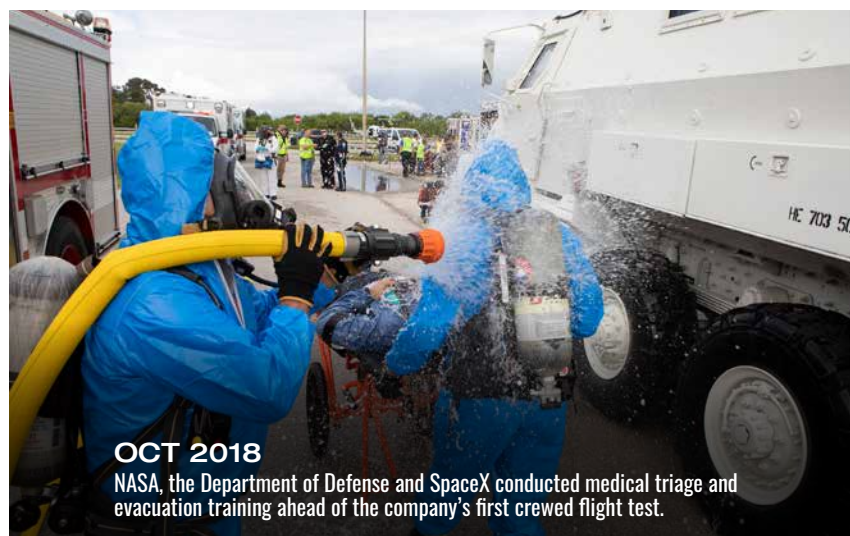
**OCT 2018**  
NASA's Exploration Ground Systems (EGS) tested Launch Pad 39B's Ignition Overpressure Protection and Sound Suppression system.



**NOV 2018**  
NASA's Launch Services Program (LSP) – the first agency program managed at Kennedy – celebrated its 20th anniversary.



**DEC 2018**  
NASA, Northrop Grumman and Lockheed Martin performed a ground firing static test of the abort motor for Orion's Launch Abort System (LAS).



**OCT 2018**  
NASA, the Department of Defense and SpaceX conducted medical triage and evacuation training ahead of the company's first crewed flight test.



**DEC 2018**  
SpaceX launched a Falcon 9 rocket and Dragon spacecraft on the company's 16th commercial resupply services (CRS) mission to the space station.



**NOV 2018**  
The European-built service module that will help power Orion in lunar orbit arrived at Kennedy from Bremen, Germany.



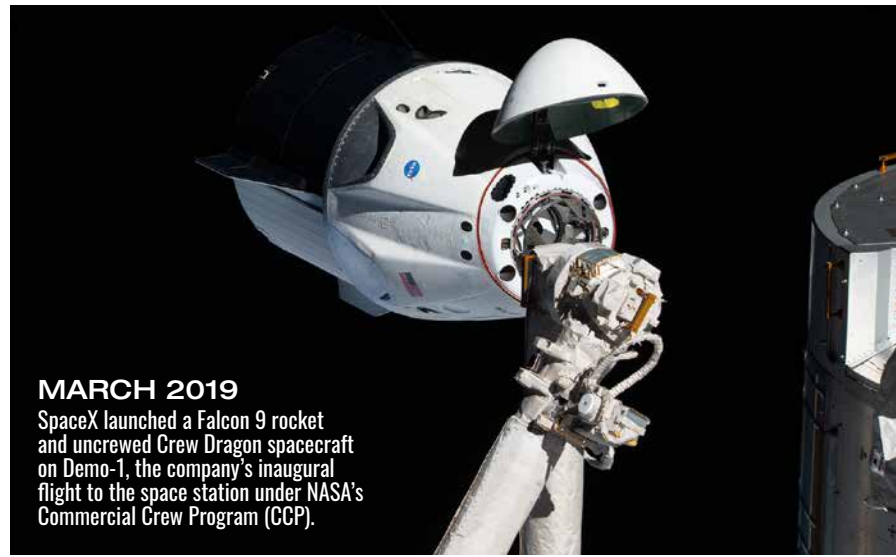
**OCT-NOV 2018**  
NASA and the U.S. Navy conducted Underway Recovery Test 7, validating equipment and procedures to retrieve the Orion spacecraft from the Pacific Ocean after Artemis I.



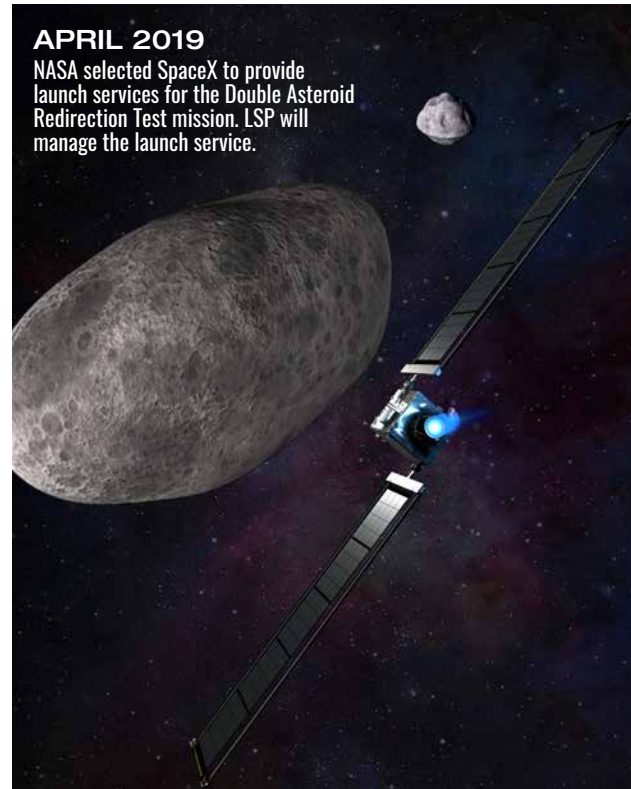
**DEC 2018**  
The Artemis I launch team rehearsed the terminal countdown in Firing Room 1 of Kennedy's Launch Control Center.



# Top 30 Significant Events



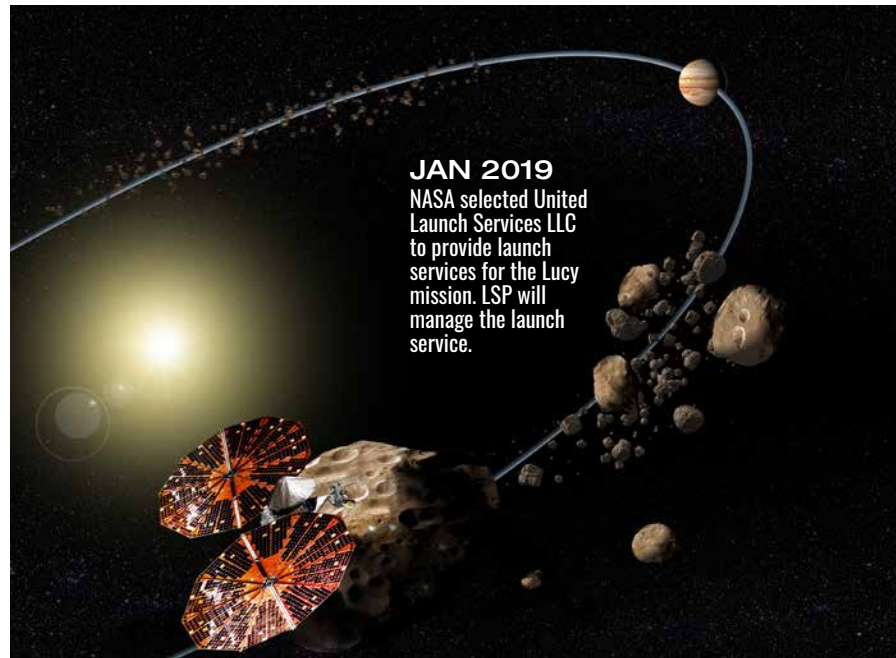
**MARCH 2019**  
SpaceX launched a Falcon 9 rocket and uncrewed Crew Dragon spacecraft on Demo-1, the company's inaugural flight to the space station under NASA's Commercial Crew Program (CCP).



**APRIL 2019**  
NASA selected SpaceX to provide launch services for the Double Asteroid Redirection Test mission. LSP will manage the launch service.



**MAY 2019**  
Orion's service module for Artemis I completed a series of acoustic tests. Acoustic levels ranged from 128 to 140 decibels – as loud as a jet engine.



**JAN 2019**  
NASA selected United Launch Services LLC to provide launch services for the Lucy mission. LSP will manage the launch service.



**MAY 2019**  
SpaceX launched a Falcon 9 rocket and Dragon cargo spacecraft on the company's 17th CRS mission to the space station.



**JUNE 2019**  
The mobile launcher rolled from the Vehicle Assembly Building (VAB) to Launch Pad 39B for final testing prior to Artemis I.



**JUNE 2019**  
NASA selected Bechtel National Inc. to design and build a second mobile launcher (ML2) for EGS.



**APRIL 2019**  
NASA and the Department of Defense conducted the first at-sea exercise with Boeing's CST-100 Starliner training capsule ahead of the company's first crewed CCP flight test.



**JUNE 2019**  
A SpaceX Falcon Heavy rocket carried 24 satellites – including four science and tech demonstrations for NASA – on the Department of Defense's Space Test Program-2 mission.



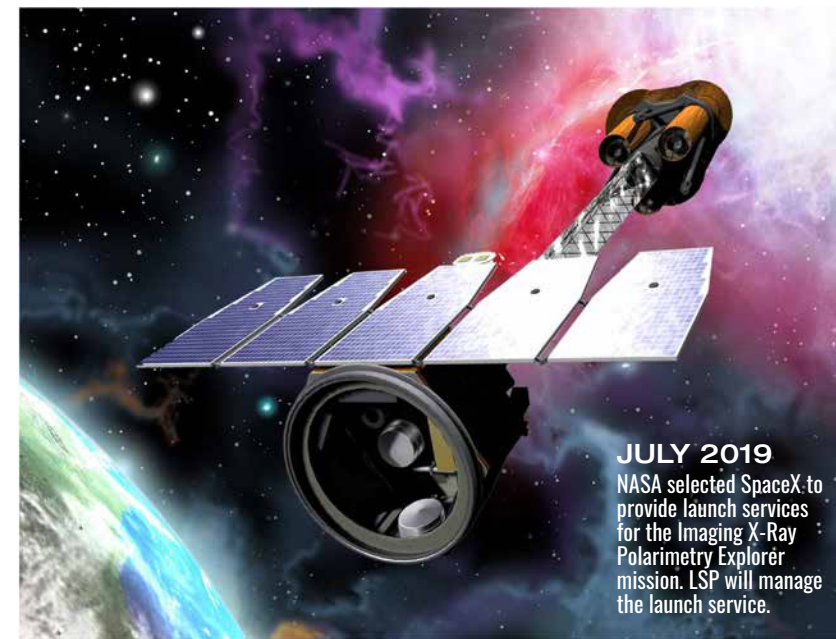
# Top 30 Significant Events



**JULY 2019**  
NASA launched a test version of the Orion and LAS atop a Northrop Grumman-provided booster on the Ascent Abort-2 flight test.



**JULY 2019**  
To commemorate the 50th anniversary of Apollo 11, Vice President Mike Pence visited Kennedy and unveiled NASA's Orion crew capsule for Artemis I.



**JULY 2019**  
NASA selected SpaceX to provide launch services for the Imaging X-Ray Polarimetry Explorer mission. LSP will manage the launch service.



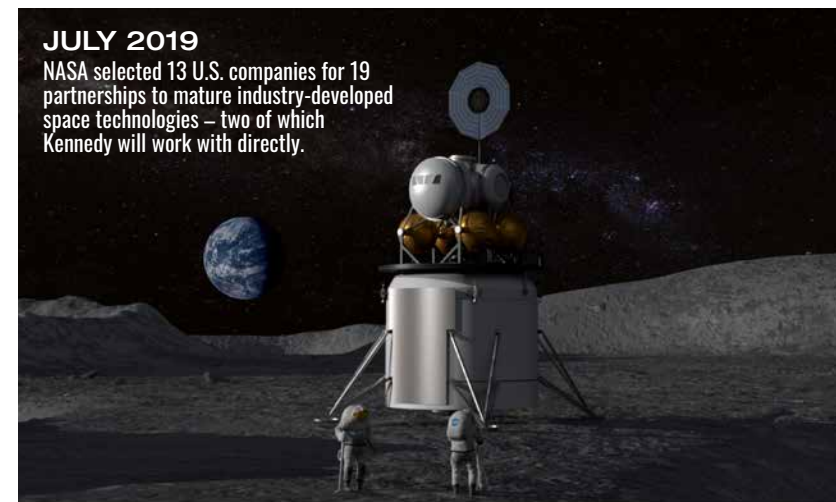
**JULY 2019**  
SpaceX launched a Falcon 9 rocket and Dragon cargo spacecraft on the company's 18th CRS mission to the space station.



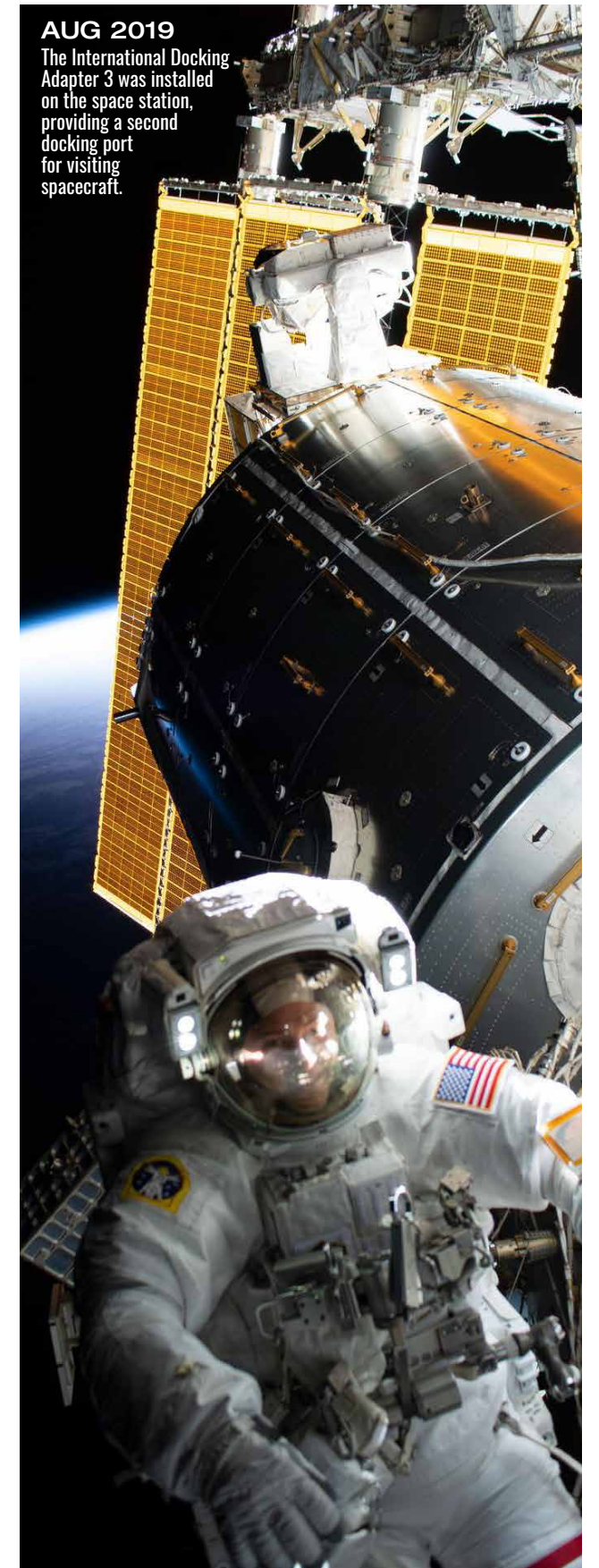
**JULY 2019**  
EGS completed the first in a series of water flow tests with the mobile launcher at Launch Pad 39B to prepare for launch of the Space Launch System (SLS) rocket on Artemis I.



**JULY 2019**  
NASA led an emergency escape and triage simulation with Boeing and United Launch Alliance in preparation for crewed flights to the space station.



**JULY 2019**  
NASA selected 13 U.S. companies for 19 partnerships to mature industry-developed space technologies – two of which Kennedy will work with directly.



**AUG 2019**  
The International Docking Adapter 3 was installed on the space station, providing a second docking port for visiting spacecraft.



# Top 30 Significant Events



**AUG 2019**  
NASA and SpaceX practiced removing astronauts from the Crew Dragon using a spacecraft mock-up and the company's Go Searcher recovery ship.



**AUG 2019**  
Northrop Grumman signed a Reimbursable Space Act Agreement to use VAB High Bay 2 and Mobile Launcher Platform 3 for its Omega rocket.



**SEPT 2019**  
Boeing, NASA and the U.S. Army conducted landing and recovery rehearsals in New Mexico for upcoming CST-100 Starliner missions to the space station.



**SEPT 2019**  
A full-scale mock-up of the SLS rocket's core stage arrives at Kennedy to help teams validate equipment and processing procedures.



*Keeping a wary eye on the photographer, an osprey perches on a tree branch near one of Kennedy's many waterways.*



## Historic First

Northrop Grumman becomes the first commercial tenant to use the Vehicle Assembly Building and Mobile Launcher Platform-3 for assembly of its new Omega rocket.



## Small Satellites, Big Opportunities

Kennedy Space Center establishes Launch Complex 48 to increase access to space for small satellites.



## Growing Capabilities

Blue Origin begins a 90-acre expansion of its manufacturing facility.



# CENTER PLANNING AND DEVELOPMENT



## Putting Down Roots

SpaceX launches plans for a 67-acre expansion, including its own launch control center.



## Bright Idea

Florida Power & Light is increasing its spaceport solar farm to generate an additional 74.5 megawatts.



## People's Choice Winner

Voters choose Kennedy Space Center Director Bob Cabana and his team for their vision and leadership in transforming the center into our nation's premier, multi-user spaceport.



# America's Premier Multi-User SPACEPORT

90 ACTIVE PARTNERS WITH 270+ AGREEMENTS AND COUNTING

## SPACE AVAILABLE

Kennedy Space Center released a [Notice of Availability \(NOA\)](https://go.nasa.gov/2LJIEo2) for undeveloped land to support activities in launch operations, assembly, testing and processing, renewable energy, research and development, support services, and vertical launch and landing. The announcement is part of Kennedy's multi-user spaceport objectives and is based on effectively utilizing land assets identified in the center's 20-year Master Plan. This NOA has a two-year window of opportunity that began June 2, 2018, and expires June 1, 2020. Interested parties can respond to the NOA anytime during the open period.

### SOLAR PANEL PROJECT

Florida Power & Light is leasing 476 acres to expand the Solar Panel Project. This agreement will provide an additional 74.5-megawatt solar field.

### LAND USE FOR LAUNCH OPERATIONS

SpaceX signed an Enhanced Use Lease for the use of 66.99 acres of undeveloped land to create a centralized campus, booster and fairing production and storage, and a launch control center.

### MORE MANUFACTURING

Blue Origin signed an Enhanced Use Lease for approximately 90 acres to expand its orbital vehicle manufacturing complex.

### A GROWING SPACEPORT

Center leaders are updating Kennedy's Master Plan, a crucial element in the center's continued evolution as a dynamic multi-user spaceport. These updates will further support the center's growth as an environment where government, commercial partners and academia will succeed, and ensure Kennedy will continue to serve as humanity's gateway to the universe, beginning with efforts to land the first woman and next man on the Moon.

- AVAILABLE LAND
- PARTNERSHIP LAND/ASSETS
- GOVERNMENT USE LAND/ASSETS



**KENNEDY'S FIRST MULTI-USER FACILITY**  
Kennedy entered into an agreement with Northrop Grumman to lease High Bay 2 of the Vehicle Assembly Building (VAB) for assembly and testing of the company's OmegA launch vehicle. The VAB also will host the assembly of NASA's Space Launch System rocket, making this the spaceport's first-ever shared-use facility. The partner also secured a services agreement for Mobile Launcher Platform-3.

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# Commercial Crew Program

NASA's Commercial Crew Program completed its first uncrewed flight test in FY 2019, advancing NASA's goal of returning human spaceflight launches to U.S. soil on commercially built and operated American rockets and spacecraft. Along with its commercial partners, Boeing and SpaceX, the program is supporting the agency as it prepares for a human presence on the Moon with the ultimate goal of sending astronauts to Mars.

In March, the world witnessed SpaceX's Demo-1 mission, an uncrewed flight test of Crew Dragon that launched aboard a Falcon 9 rocket to the International Space Station and autonomously docked to the orbiting laboratory. After five days, it returned to Earth, splashing down in the Atlantic Ocean. Demo-1 demonstrated SpaceX's crew transportation system capabilities and brought the program a significant step closer to launching crew once again from Florida's Space Coast.

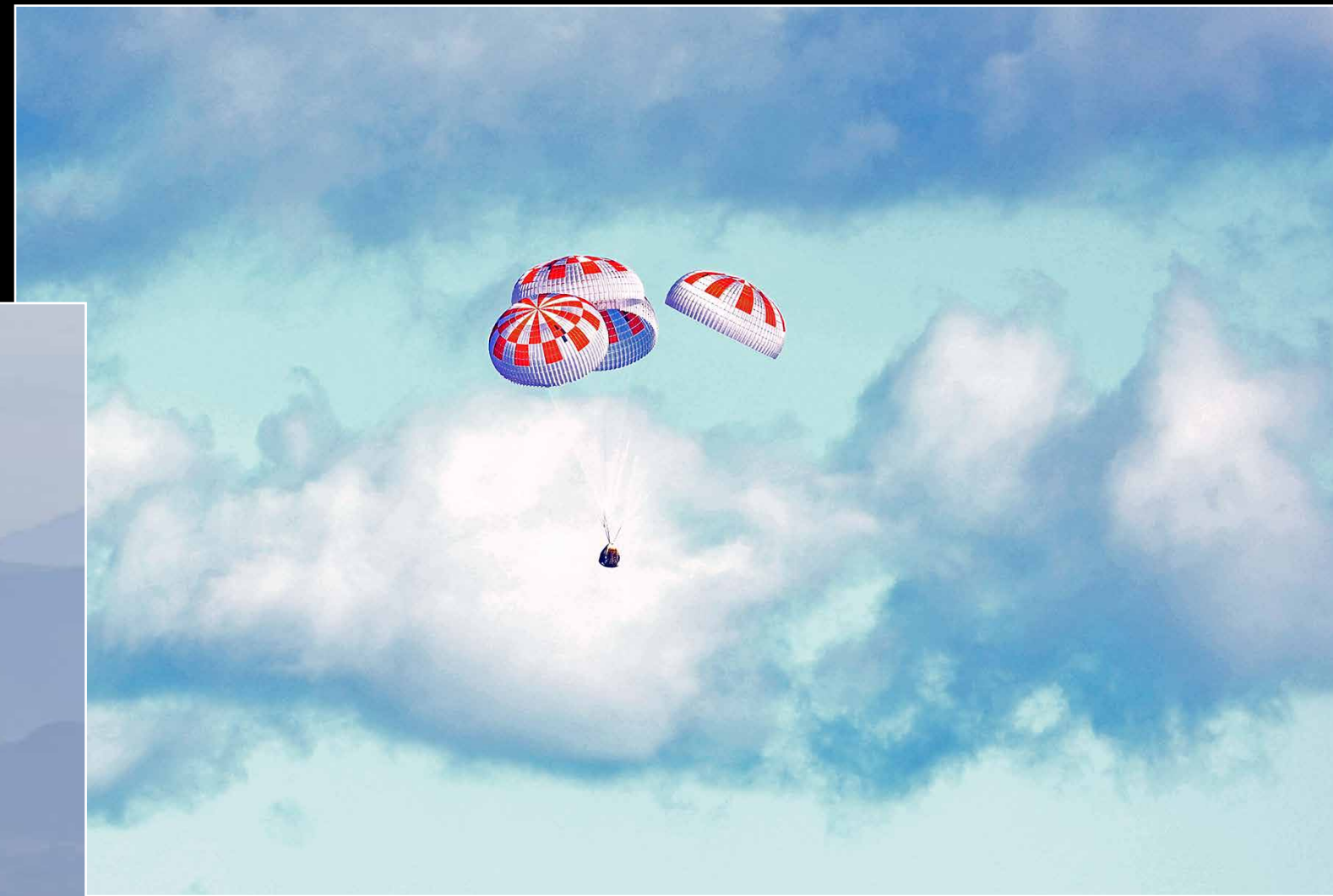
Additional testing, training and processing advanced in preparation for the upcoming test flights, including abort tests for each provider.

Boeing completed initial production of three CST-100 Starliner spacecraft inside the company's Commercial Crew and Cargo Processing Facility at Kennedy, and conducted environmental qualification testing to validate Starliner's ability to withstand the harsh environments of launch, ascent and spaceflight. Starliner's propulsion system was put to the test at White Sands Test Facility in New Mexico during an integrated service module hot fire test. Boeing also completed the initial qualification series of parachute drop tests using a high-altitude balloon and, working with NASA, completed a series of "lawn dart" drop tests to continue proving the reliability of Starliner's parachute systems. Boeing, ULA, NASA and the Department of Defense (DoD) teamed up for integrated rehearsals of mission phases and various emergency escape and recovery scenarios. Crew training for the Crew Flight Test and first operational mission also continues, and mission teams began their dress rehearsals for various phases of the upcoming missions.

The United Launch Alliance Atlas V rocket that will launch Starliner on its uncrewed Orbital Flight Test arrived in Cape Canaveral, Florida, and is ready for final integration before launch. The Atlas V set to launch



*Boeing's CST-100 Starliner's parachute system is tested above the U.S. Army's Yuma Proving Ground in Arizona on June 26, 2019.*



*SpaceX's Crew Dragon is guided by four parachutes toward the Atlantic Ocean on March 8, 2019, after returning from the International Space Station on the Demo-1 mission.*

astronauts on Boeing's Crew Flight Test also arrived in Florida for processing ahead of the mission.

SpaceX continued manufacturing its Crew Dragon spacecraft inside the company's headquarters facility in Hawthorne, California. The company conducted a series of parachute tests that provided unique insight into parachute loading, behavior and reliability, and helped to further refine parachute design.

Teams from NASA, SpaceX and DoD continued to rehearse launch day operations, mission phases and communication in both normal and emergency scenarios. Teams also practiced removing astronauts from Crew Dragon on the company's recovery boat, rehearsing steps they will take after splashdown of SpaceX's Demo-2 mission, which will be the company's first with crew aboard.

The nine U.S. astronauts selected for commercial crew missions worked closely with Boeing and SpaceX to ensure they are prepared for any situation that may arise during their mission and to live and work aboard the space station.

Upcoming flight test dates for each provider are under review. Following each test, NASA will review the performance data to ensure each upcoming mission is as safe as possible. After completion of all test flights, NASA will continue its review of the systems and flight data for certification ahead of the start of regular flights with crew to the space station.



NASA astronauts Shannon Walker, in front, and Bob Behnken participate in a formal verification of SpaceX's emergency escape system on Sept. 18, 2019, at Kennedy's Launch Complex 39A.



Boeing's CST-100 Starliner prepares for electromagnetic interference and electromagnetic contamination testing in a specialized test chamber at the company's Space Environment Test Facilities in El Segundo, California.



Boeing astronaut Chris Ferguson helps NASA astronauts Nicole Mann (left) and Mike Fincke (right) train for a spacewalk inside the International Space Station Airlock Mockup at NASA's Johnson Space Center in Houston in February 2019. Mann, Ferguson and Fincke are assigned to Boeing's Crew Flight Test.



A SpaceX Falcon 9 rocket, topped by the company's Crew Dragon spacecraft, stands on the launch pad at Kennedy's Launch Complex 39A, Feb. 28, 2019, in preparation for the March 2 launch of Demo-1.



# Launch Services Program

NASA's Launch Services Program (LSP), based at Kennedy Space Center, specializes in connecting payload entities with launch vehicle providers. The LSP team provides reliable, competitive and user-friendly launch services in the commercial arena to satisfy agencywide space transportation requirements and maximize the opportunities for mission success.

LSP has a role in NASA's return to the Moon. For the agency's Artemis architecture, LSP is serving in a major consulting role for the Gateway Logistics Element, the Human Landing System, the Habitation and Logistics Outpost and the Power and Propulsion Element, as well as providing mission management to deliver the Canadian Deep Space Exploration Robotic System to the Gateway. The team also is leveraging its expertise in Venture Class Launch Services (VCLS) for precursor lunar CubeSat missions to reduce technical risk in advance of crewed Artemis campaigns.

NASA awarded three missions in FY 2019: Lucy, targeted to launch in October 2021 aboard a United Launch Alliance Atlas V 401 rocket; as well as Double Asteroid Redirection Test (DART), targeted to launch in June 2021, and Imaging X-Ray Polarimetry Explorer (IXPE), targeted to launch in April 2021, both aboard SpaceX Falcon 9 rockets. LSP will manage the launch service for all three missions, with Lucy and IXPE launching from Florida, and DART launching from Vandenberg Air Force Base in California.

The program also supports NASA's science missions, including the James Webb Space Telescope. In addition, it manages Educational Launch of Nanosatellites (ELaNa) missions, which launch complements of small satellites, known as CubeSats, selected for flight by the agency's CubeSat Launch Initiative (CSLI). In FY 2019, 20 CubeSats were launched during seven missions: ELaNa 16 in November 2018; ELaNa XIX, 21 and 24 in December 2018; ELaNa 26 in April 2019; ELaNa XV in June 2019; and ELaNa 27 in July 2019. ELaNa XIX was launch vehicle provider Rocket Lab's first mission for NASA under a VCLS contract.

LSP selected five companies to provide commercial CubeSat dispenser hardware and mission integration services as part of the CubeSat 3 contract. The program supports CSLI by providing dispenser hardware and mission integration services to CubeSat development teams from educational institutions, non-profit organizations and NASA centers.

LSP's Hangar AE, located at Cape Canaveral Air Force Station, supported a total of 21 launches. These included launches for NASA's Commercial Resupply Services, which replenish the International Space Station; NASA's Commercial Crew Program's SpaceX Demo-1, which was the first orbital test of the Crew Dragon spacecraft; the Department of Defense; and commercial companies. Hangar AE also supports the Commercial Crew Program and Space Launch System teams by documenting communication and telemetry requirements.

Throughout FY 2019, LSP continued to work toward the launch of the Ionospheric Connection Explorer (ICON), which will study the layer of charged particles high in our atmosphere where Earth's weather meets space weather. NASA and Northrop Grumman launched ICON on a Pegasus XL rocket from Cape Canaveral Air Force Station in October 2019.



Above: A Rocket Lab Electron rocket lifts off from Launch Complex-1 at Māhia Peninsula in New Zealand carrying NASA's ELaNa XIX payload. The launch marks the first flight of a payload under NASA's Venture Class Launch Services, managed by LSP.



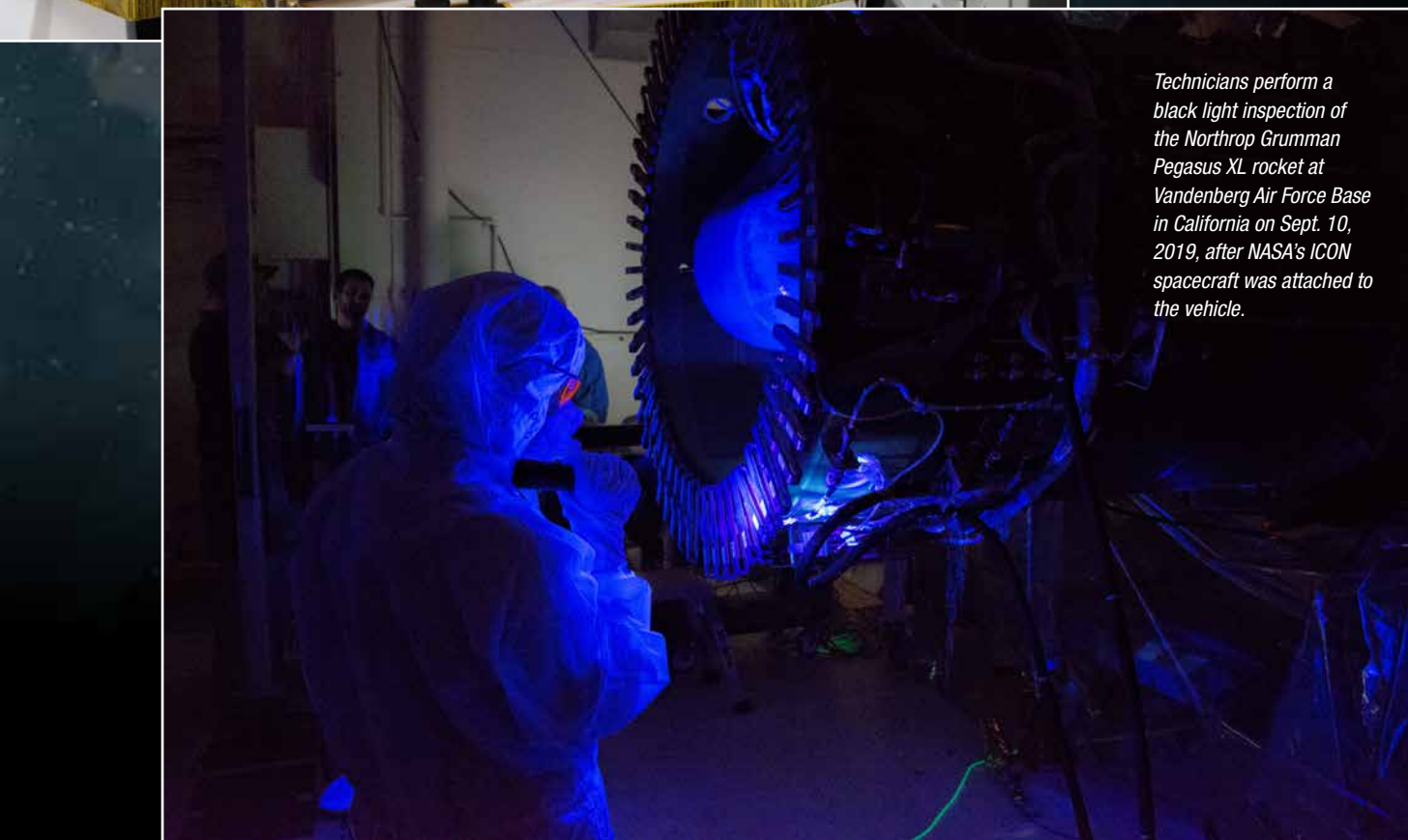
Left: Technicians extend the solar array on NASA's ICON spacecraft during a deployment test at Vandenberg Air Force Base in California on Aug. 10, 2019.



Below: The ELaNu XIX payload is prepared for encapsulation inside the Rocket Lab Electron rocket payload fairing on Dec. 1, 2018, at the company's facility in New Zealand.



Above: Technicians attach NASA's ICON spacecraft to the Northrop Grumman Pegasus XL rocket at Vandenberg Air Force Base in California on Sept. 10, 2019.



Technicians perform a black light inspection of the Northrop Grumman Pegasus XL rocket at Vandenberg Air Force Base in California on Sept. 10, 2019, after NASA's ICON spacecraft was attached to the vehicle.



Kennedy and the surrounding community hosted an array of special events to celebrate the 50th anniversary of the launch of Apollo 11 – the United States' first lunar landing mission.



- Top Left: Kennedy Space Center Director and retired NASA astronaut Bob Cabana rides in a Corvette during the "Man on the Moon" astronaut parade in Cocoa Beach, Florida.
- Top Right: Apollo 11 astronaut Michael Collins, left, and Kennedy Space Center Director Bob Cabana look at NASA photos hanging on the wall of the astronaut crew quarters.
- Middle: On July 16, 2019, the 50th anniversary of the Apollo 11 launch to the Moon, launch team members from Apollo 11 and Artemis I mingled in Launch Control Center Firing Room 1. From left are John Tribe, Apollo 11 launch team member; Kennedy Space Center Director Bob Cabana; Artemis I Launch Director Charlie Blackwell-Thompson; Harrison Schmitt, Apollo 17 astronaut; Apollo 11 astronaut Michael Collins, with his daughters Ann (left) and Kate (right); and Kelvin Manning, associate director, technical.
- Bottom Left: Artemis I Launch Director Charlie Blackwell-Thompson, left, talks with Apollo-era launch team member JoAnn Morgan in Launch Control Center Firing Room 1.
- Bottom Right: Apollo 11 astronaut Michael Collins, right, speaks to Kennedy Space Center Director Bob Cabana at Launch Complex 39A.



# ARTEMIS: Exploration Ground Systems

NASA's Exploration Ground Systems (EGS) continues to prepare the spaceport in support of the Artemis program. Exploration objectives are being achieved by developing the necessary ground systems, infrastructure and operational approaches. Fiscal Year 2019 included preparations for the launch and recovery of Orion on the Space Launch System (SLS), as well as support for other rockets that could potentially launch from Kennedy Space Center.

The Artemis launch team completed several formal training simulations that will certify the team for the inaugural launch of the SLS rocket and Orion spacecraft. Led by Launch Director Charlie Blackwell-Thompson, the team performed demonstrations including a final countdown simulation and one that mimicked loading the SLS with liquid oxygen and hydrogen. These exercises ensure the launch team knows the new countdown procedures and can handle surprise issues in real-time. Teams also have been working to complete launch software while upgrades are finishing up in Firing Rooms 1 and 2.

Throughout the year, mechanics completed necessary engine maintenance on crawler-transporter 2, ensuring it will be ready for Artemis I. The massive, tracked vehicle is powered by large electrical power engines and two 16-cylinder American Locomotive Company (ALCO) engines. Mechanical technicians supporting the agency's Test and Operations Support Contract spent several days rebuilding the vehicle's fuel pump assemblies on both ALCO engines. They also installed new oil pumps that will lubricate the ALCOs from the top down before they're started, minimizing future wear. The crawlerway also is going through conditioning, making sure the deep composition of river rock is stable enough to handle the incredible loads that include the mobile launcher, SLS and Orion spacecraft.

The mobile launcher rolled to Pad 39B in June for final tests and checkouts throughout the summer, including umbilical swing arm tests and a series of wet flow tests to verify the sound suppression system. Teams



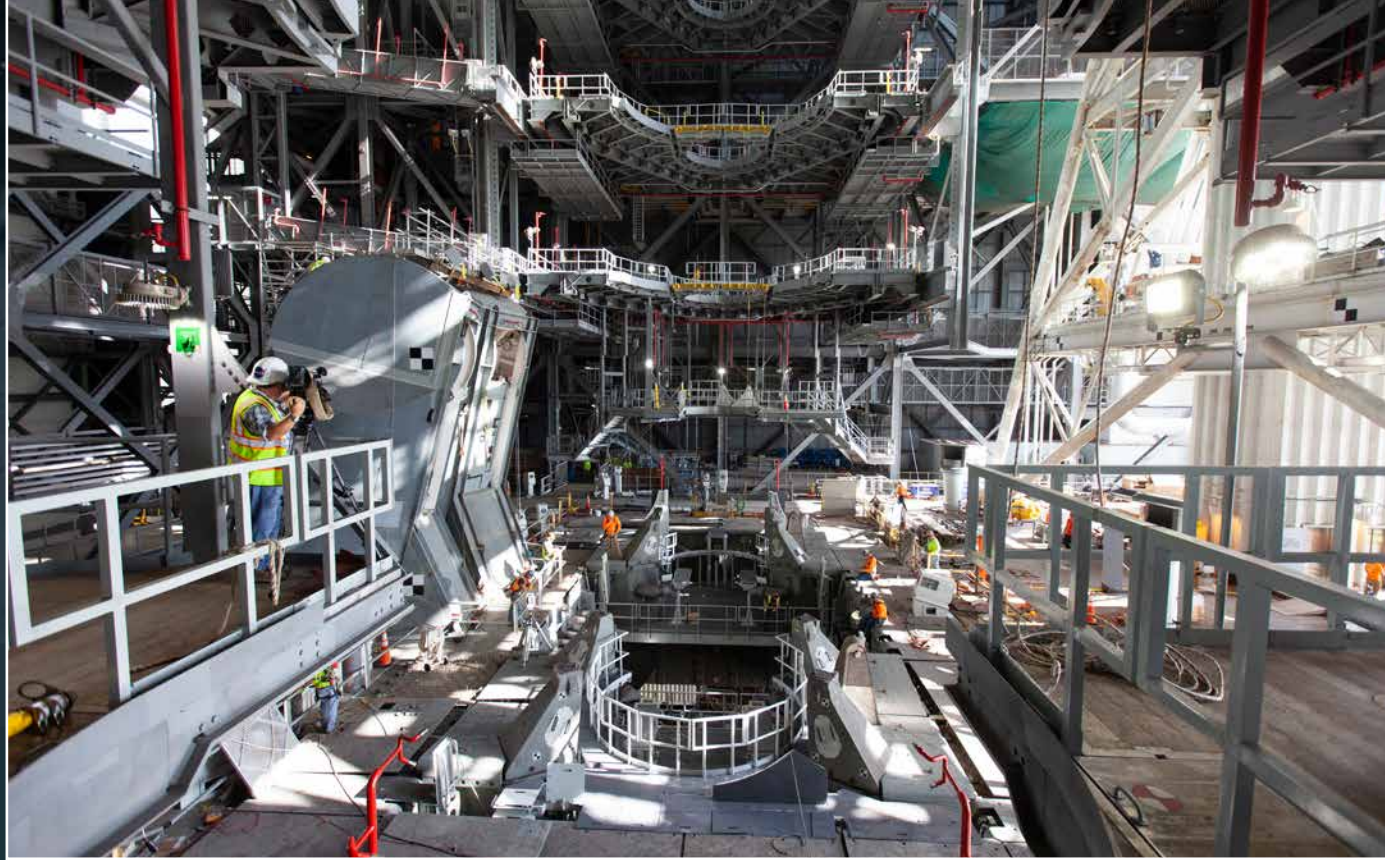
Left: A test version of the Orion capsule is guided onto its cradle in the well deck of the USS John P. Murtha on Nov. 3, 2018, during Underway Recovery Test-7.

Below: Pat Brown, left, and William Vardaman, mechanical technicians with the Jacobs contracting team, perform engine maintenance on NASA's crawler-transporter 2 on March 26, 2019, in the crawler yard located in the Launch Complex 39 area.

Exploration Ground Systems conducts a water flow test with the mobile launcher at Launch Pad 39B on July 2, 2019. This was the first in a series of tests to verify the sound suppression system is ready for launch of NASA's Space Launch System and Orion spacecraft on the first Artemis mission.







verified systems on the launcher and the pad were working together appropriately. Just before the rollout, the engine service platform that will provide access to the core stage of the SLS was installed. EGS also conducted a Tail Service Mast Umbilical drop test inside the Vehicle Assembly Building to verify the umbilicals will disconnect before launch. NASA selected Bechtel National Inc. of Reston, Virginia, to design and build a second mobile launcher, known as Mobile Launcher 2, or ML2. Design is underway.

A variety of renovations at Pad 39B were completed in August, including the final installation of support columns for the mobile launcher. Other additions include more than 90,000 new heat-resistant bricks on the walls of the flame trench and installation of a new flame deflector. EGS broke ground in December 2018 for a new liquid hydrogen tank at the pad that will be the largest in the world. The storage facility will hold 1.25 million gallons of the propellant.

EGS participated with the Department of Defense in Underway Recovery Test-7 (URT-7) to practice recovering the Orion capsule once it returns from space. During URT-7, the recovery team embarked on the USS John P. Murtha, an amphibious U.S. Navy ship, in the Pacific Ocean with the main goal of ensuring all of their new recovery equipment was validated and up to the task.



*The engine service platform that will provide access to the core stage of NASA's Space Launch System rocket is lifted up in the center of the mobile launcher in the Vehicle Assembly Building's High Bay 3 on June 18, 2019.*

*Members of the Artemis I launch team, including personnel with NASA's Exploration Ground Systems and Jacobs Test and Operations Contract, participate in validation testing inside Firing Room 1 in Kennedy's Launch Control Center on July 11, 2019.*

*The mobile launcher is moved from the Vehicle Assembly Building and stands on the pad surface at Launch Complex 39B on June 28, 2019, for final checkouts and testing before Artemis I.*





# ARTEMIS: Orion Production Operations

The Orion spacecraft is an integral part of the Artemis missions to the Moon and beyond. The Orion production team of engineers and technicians from NASA and Lockheed Martin are working around the clock building the spacecraft that will take humanity farther than ever before. In FY 2019, the team achieved major processing accomplishments and testing milestones, bringing the agency closer to the first launch of the Artemis program.

## GIANT LEAPS TOWARD ORION'S FIRST ARTEMIS MISSION

This year kicked off with the Nov. 6, 2018, delivery of the European Service Module (ESM), the powerhouse that will help the Orion spacecraft venture beyond the Moon. This was a huge achievement for the NASA Orion team and its European Space Agency (ESA) counterparts. The ESM was then hoisted into its lift station and integrated with the Crew Module Adapter – built at Kennedy – that connects the spacecraft to the ESM. Together, these two pieces of hardware make up the entire service module for Orion.

The service module team and its colleagues from ESA and Airbus conducted several tests, including initial power up, thermal cycle, acoustics and a temporary install of the solar array wings for deployment testing. Meanwhile, the team achieved several closeout milestones on the Orion

crew module for Artemis I. Installed onto the crew module were both the side hatch, which will be the astronauts' entry and exit point at the launch pad, and docking hatch panel, for crew access to Gateway in space. Once all main flight components were secured, the vehicle went through acoustic testing, in which it was blasted with 141 decibels of extreme vibrations, and its weight and center of gravity measurements were taken.

The service module and crew module passed these tests with flying colors, and both were declared complete in July 2019.

The crew module was then structurally mated to the service module in the Final Assembly and Test cell, creating what is referred to as the Crew and Service Module (CSM). All fluid and electrical lines were connected, enabling the vehicle to "talk" to its powerhouse.

The CSM underwent an initial test campaign, including its first power-up and a series of functional tests and mission-test scenarios utilizing the ground support equipment. The tile protection system and backshell panels then were installed, giving the stack a flight-ready look. The stack will be transported to NASA's Plum Brook Station in Sandusky, Ohio, early in FY 2020 for space environmental testing.

In conjunction with the Orion processing milestones for Artemis I achieved inside the Neil Armstrong Operations and Checkout Facility's



*The completed Orion crew capsule for Artemis I is backdropped by an American flag inside Kennedy's Neil Armstrong Operations and Checkout Building on July 19, 2019. Vice President Mike Pence visited and gave remarks at the facility to commemorate the 50th anniversary of the Apollo 11 Moon landing and to announce the Orion capsule's completion.*



*The test version of Orion, attached to the Launch Abort System, launches on July 2, 2019, atop a Northrop Grumman-provided booster from Launch Pad 46 at Cape Canaveral Air Force Station.*



*The cover of the shipping container carrying the heat shield for Orion's Artemis II, NASA's first crewed Artemis mission, is lifted away in Kennedy's Neil Armstrong Operations and Checkout Building high bay on July 9, 2019.*



high bay, work on the mission's Launch Abort System was underway in the Launch Abort System Facility (LASF). The system's three motors – the Attitude Control Motor, Jettison Motor and Abort Motor – arrived for processing. These segments currently are being integrated and will be ready to mate with the CSM in 2020.

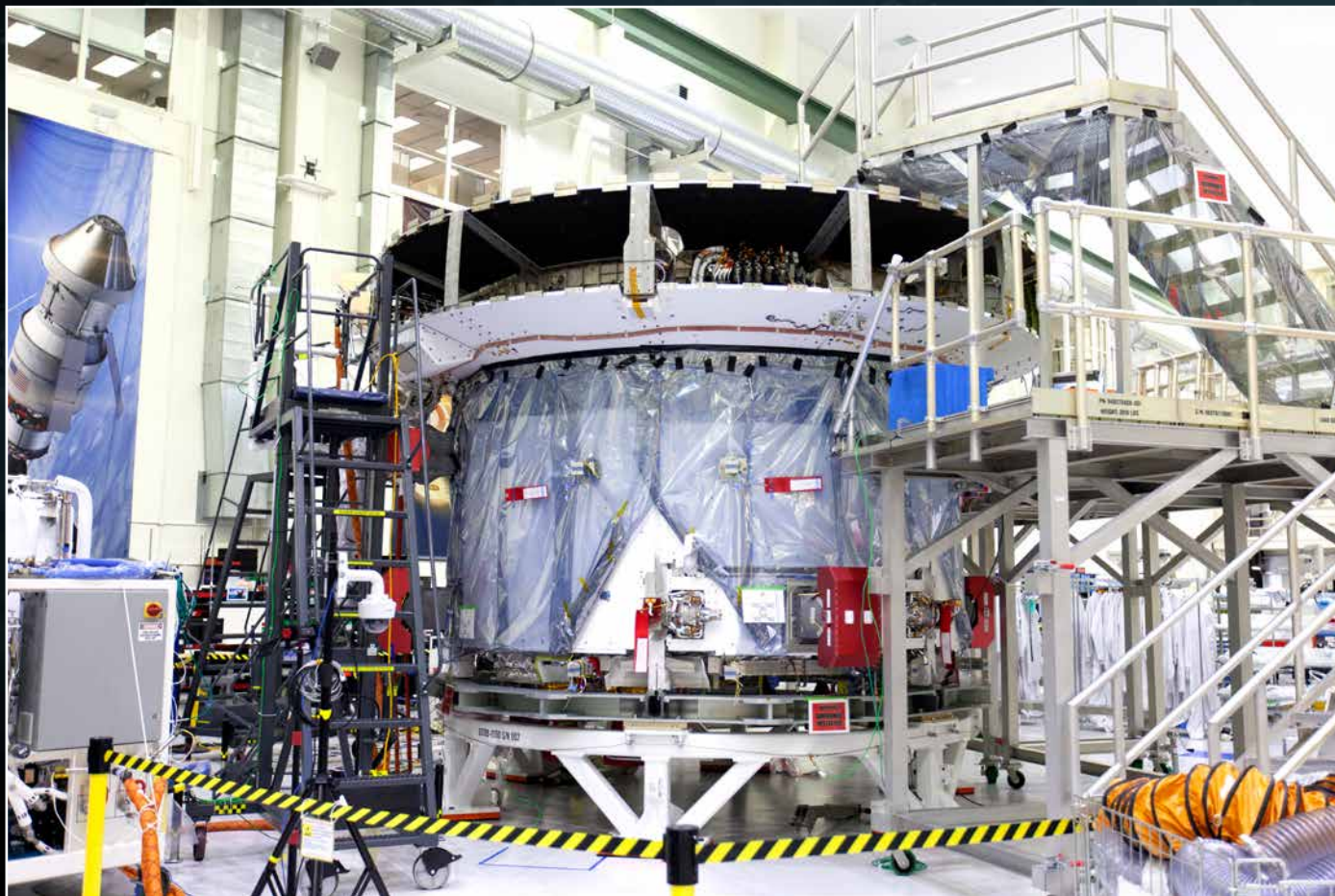
## BUILDING THE ORION SPACECRAFT FOR ARTEMIS II – THE FIRST ARTEMIS SPACECRAFT TO SEND CREW AROUND THE MOON

While production on Artemis I is coming to a close as the mission approaches, the Orion spacecraft for Artemis II, the first crewed mission, is well underway at Kennedy. The team working on the crew module for Artemis II has made great strides toward completing the primary structure and adding critical secondary structure elements to the main pressure vessel that arrived for processing from Michoud Assembly Facility in Louisiana.

The state-of-the-art heat shield, measuring roughly 16 feet in diameter, arrived at Kennedy in July 2019 for assembly and integration with the crew module. The heat shield first went through a fitting exercise with the vehicle. Because the heat shield arrived as a substructure base, or skeleton, it will be built upon with Avcoat blocks and insulation to provide Orion and its crew protection from the extreme heat of re-entry.

## SAFETY CHECK

On July 2, 2019, the Orion team successfully demonstrated the spacecraft's Launch Abort System can outrun a speeding rocket and pull astronauts to safety during an emergency during launch. Once the system was fully integrated, the launch abort system stack was rolled from the LASF to Space Launch Complex 46 on Cape Canaveral Air Force Station, where it was integrated with a Northrop Grumman-provided booster for Ascent Abort-2 Flight Test. All integration, processing and launch was conducted and overseen by the Orion program. The test is another milestone in the agency's preparation for Artemis missions.



Above: The European Service Module that will serve as the powerhouse for Orion on Artemis I is photographed on a work stand inside Kennedy's Neil Armstrong Operations and Checkout Building high bay, March 21, 2019.



Full Page Right: The high bay in Kennedy's Neil Armstrong Operations and Checkout Building is filled with various pieces of flight hardware for Artemis I and Artemis II in this photo taken March 21, 2019.



# ARTEMIS: Gateway Logistics Element

As part of the Artemis lunar exploration program – stepping again onto the Moon by 2024 – NASA established the Gateway Program in the spring of 2019.

The Gateway will be a small lunar outpost in orbit around the Moon, developed to enable a strategic and sustainable approach with reusable and adaptable assets that are vital to the challenging expedition to return to the Moon and to reach Mars and beyond. Akin to an airport, the Gateway will act as an operating base for extended Moon exploration missions without the need to return to Earth for resupplies, and ultimately allow deep space exploration to the Red Planet and beyond.

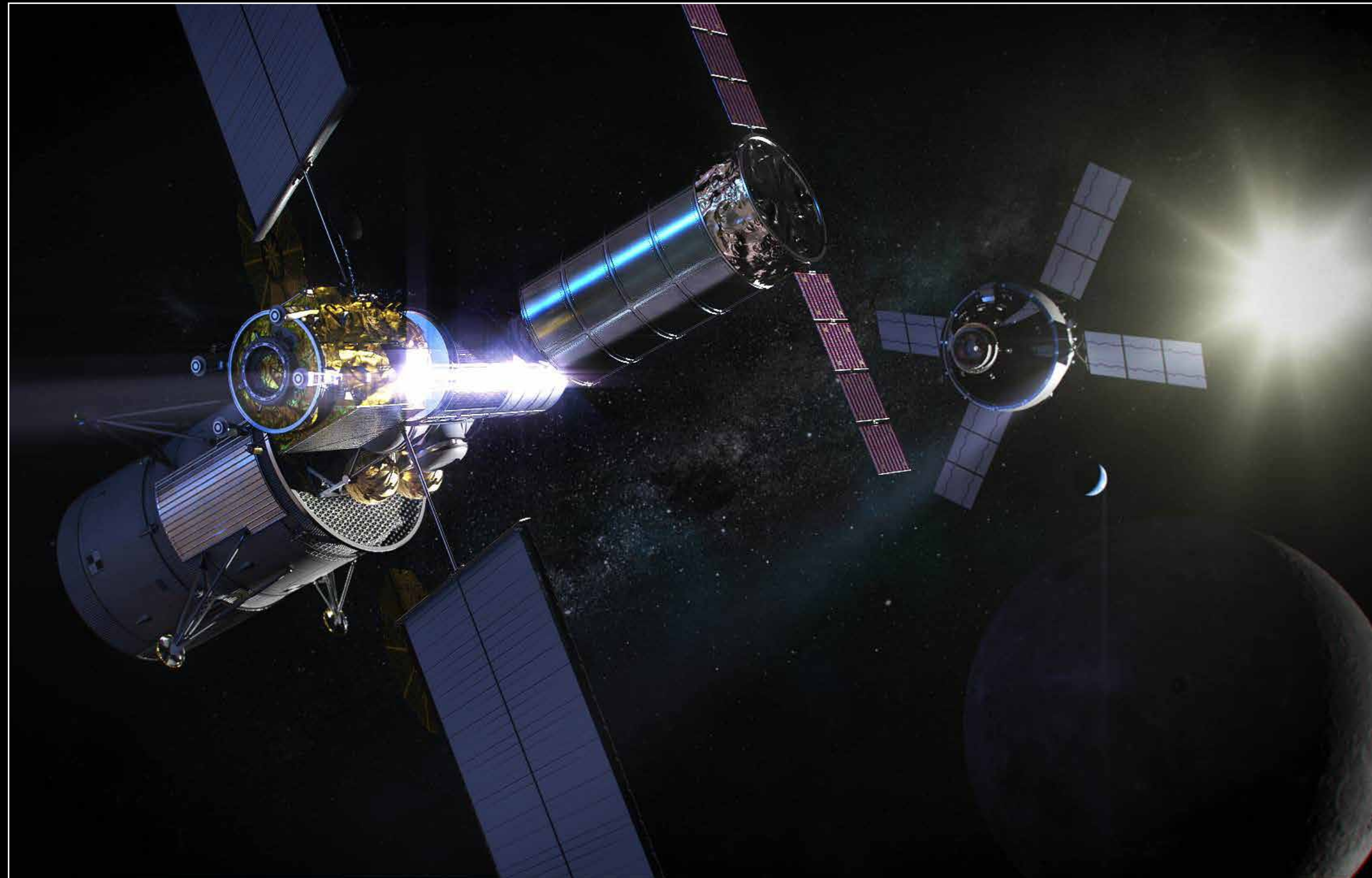
Kennedy is home to the Gateway Logistics Element (GLE), leading NASA's commercial supply chain for deep space. A Sources Sought Notice was released on Oct. 23, 2018, seeking ideas and information that would aid in crafting the acquisition strategy for supplying Gateway and the Artemis exploration campaign. The Kennedy team received approval to proceed with its procurement strategy on Dec. 17, 2018, released a draft request for proposals on June 14, 2019, and held an industry day for the Gateway Logistics Services (GLS) contract on June 26, 2019.

With the information gathered from industry, the team released the final request for proposals on Aug. 16, 2019, to procure logistics resupply capabilities to and from the Gateway in order to deliver cargo, science experiments and elements of the lunar architecture to deep space. The GLS solicitation, with an anticipated award date in early FY 2020, builds on the capabilities NASA pioneered in low-Earth orbit with commercial launch services for science and exploration spacecraft, commercial cargo resupply to the International Space Station, and the Commercial Crew Program.

The GLE is planning to officially begin operations at Kennedy in late 2019 as a collaborative team working across the spaceport, leveraging all of the specialized skills and expertise Kennedy has to offer.

The Gateway Program and GLE are crucial to facilitate multiple destinations and missions beyond low-Earth orbit, and on to Mars, within a sustainable framework that makes the most of commercial and international partnerships to meet the Artemis goal both quickly and strategically.

Kennedy will lead the logistics effort, launching sustainable deep space delivery for exploration.



*In this artist concept, NASA's Orion spacecraft, right, approaches the Gateway in orbit around the Moon.*



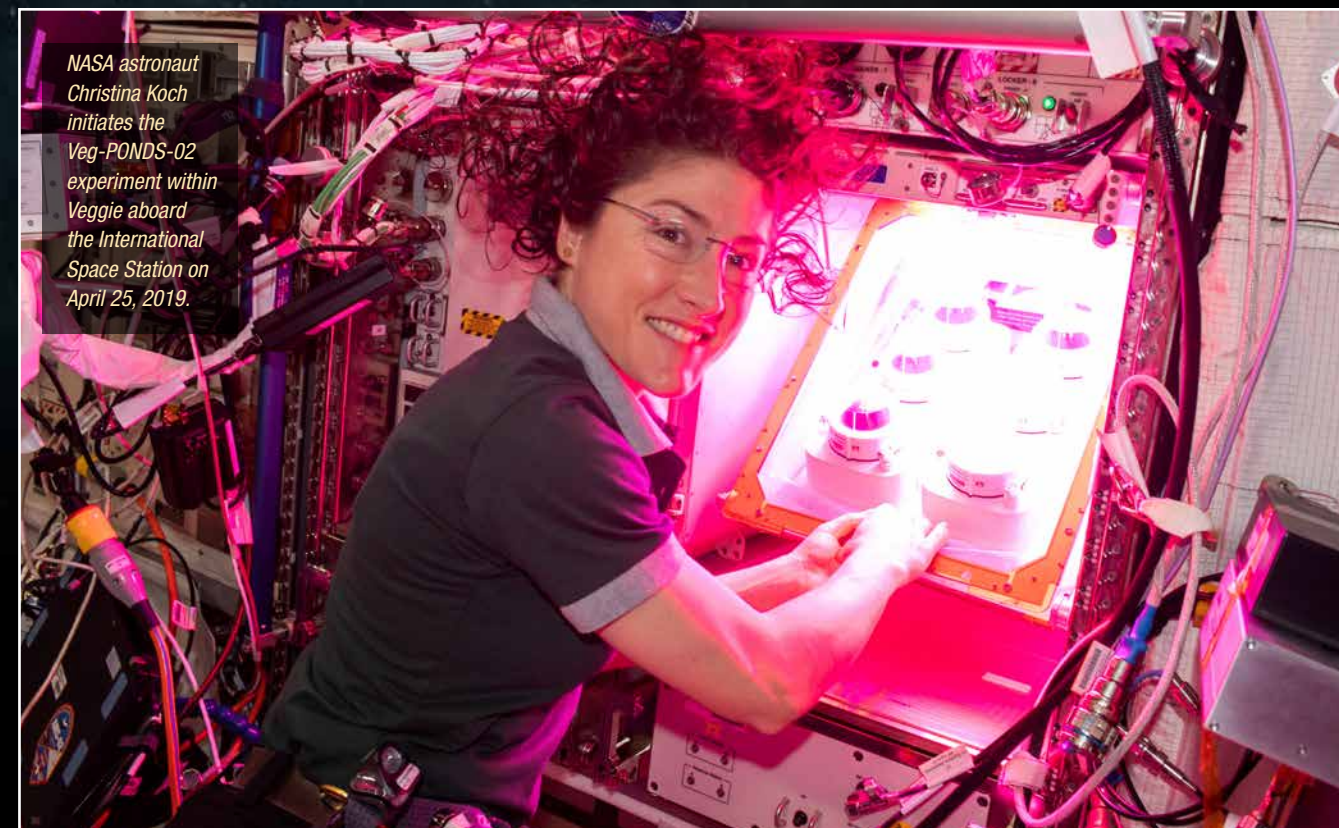
# Exploration Research and Technology

Kennedy Space Center's Exploration Research and Technology programs (ER&T) spent FY 2019 advancing and developing technologies that will help enable NASA to achieve its goals. ER&T activities throughout the year encompassed 100 projects – spread over 24 focus areas – supporting 14 programs, divisions and directorates across the agency. From the surface of Earth, to low-Earth orbit, to cislunar space and beyond, ER&T is solving a range of challenges.

A major development during the year was NASA's announcement of the Artemis program. ER&T responded to this accelerated plan to return to the Moon by participating in the preliminary development process for human landers in support of the work being led by NASA's Marshall Space Flight Center in Alabama. Precursor robotic missions to the Moon will demonstrate capabilities needed for lunar exploration, and ER&T is providing payloads developed at Kennedy, including the Mass Spectrometer observing lunar operations (MSolo). MSolo will be a payload on one of the agency's first Commercial Lunar Payload Services (CLPS) missions, which will attempt to land on the lunar surface in 2021. ER&T also is developing future payloads and working with commercial partners on additional CLPS payloads to support Artemis.

Returning to the Moon has many operational challenges, and ER&T is helping lead the charge on dust mitigation for Artemis. The Electrostatics and Surface Physics Lab also reached a milestone with the Electrodynamic Dust Shield, when it launched to spend a year of testing in the extreme conditions of space on the International Space Station. Additionally, ER&T's Applied Physics Lab performed stringent final evaluation and assessment of the Artemis I Orion spacecraft windows' optical performance. This was one of the last tests before Vice President Mike Pence announced that the spacecraft was complete and ready to begin preparations for flight. ER&T facilitated astronaut testing of a Gateway NextStep habitat prototype at Kennedy and supported the creation of the Gateway Logistics Element project at the Florida spaceport.

Teams working in the Space Station Processing Facility (SSPF) provided supply and utilization capabilities for orbital activities aboard the space station. ER&T ground processing crews prepared payloads for station ranging from air in the Nitrogen Oxygen Recharge Systems, to spare parts for station with orbital replacement units, to preparing experiments. Their efforts helped supply the orbiting laboratory with three launches from Kennedy and two launches from NASA's Wallops Flight Facility, as well as



NASA astronaut Christina Koch initiates the Veg-PONDS-02 experiment within Veggie aboard the International Space Station on April 25, 2019.



Mark Velasco (left) and Jared Sass assemble a custom cold heat exchanger for freezing carbon dioxide from a simulated Martian environment in Kennedy's Cryogenics Test Laboratory.

Tanegashima Space Center in Japan. ER&T ground processing crews also assisted with the Green Propellant Infusion Mission (GPIM), which is a next-generation propellant that reduces the toxic handling concerns of working with hydrazine while offering increased performance. GPIM was one of four NASA payloads and 24 satellites that launched from Kennedy as part of the Department of Defense's Space Test Program-2.

ER&T's plant researchers had a productive year, having astronauts grow and eat four new crop varieties in Veggie and start experiments with light recipes coupled with alternate harvest methods to measure how this impacts the qualities of food produced in space. The first samples

of *Arabidopsis* grown in the Advanced Plant Habitat returned from the station to Kennedy, and ground tests of radishes and hatch peppers have set positive conditions growing those plants in space.

ER&T continued its strong tradition of collaborating with industry and academia, and received recognition for the Technology Transfer Office leading the agency with 18 patent licenses. ER&T personnel also received the Federal Laboratory Consortium for Technology Transfer 2019 Interagency Partnership Award for the Autonomous Flight Termination Unit.

In FY 2019, ER&T stayed adaptable and completed a reorganization, marked the 20th anniversary of the first station module launch and formed new partnerships supporting commercial space ventures.



Mark Nurge, a physicist in Kennedy's Applied Physics Lab, stands near a laser interferometer, which is used to determine if there are acceptable levels of distortion and imperfections in windows. Nurge recently completed optical metrology testing and evaluation of all flight windows on the Orion capsule for Artemis I.





At left, the Mass Spectrometer observing lunar operations (MSolo) instrument is a commercial off-the-shelf mass instrument modified to work in space, and will be a payload on one of NASA's first Commercial Lunar Payload Services missions to the Moon. Below, NASA's Orbital Syngas Commodity Augmentation Reactor (OSCAR) is an Early Career Initiative project that studies technology to convert trash and human waste into useful gasses such as methane, hydrogen and carbon dioxide.



Above, the Restore-L payload undergoes preparations in the Space Station Processing Facility high bay. Managed by the agency's Goddard Space Flight Center in Greenbelt, Maryland, Restore-L is an in-flight robotic satellite servicer spacecraft. At right, the Granular Mechanics and Regolith Operations Lab tests the Regolith Advanced Surface Systems Operations Robot (RASSOR), a mining robot designed to extract usable elements from lunar regolith, undergoes testing in Kennedy's Swamp Works.



These are a few of the 100 projects ER&T led or supported during FY 2019.



A row of Self-Contained Atmospheric Protective Ensembles, or SCAPE suits, are hanging inside a changing room in Kennedy's Multi-Operations Support Building. SCAPE technicians practiced putting on these suits before a simulation involving loading propellants into a replicated test tank for Orion.



# NASA ENGINEERING



## SHORELINE RESTORATION

Kennedy Space Center's Engineering Directorate made significant progress on several critical upgrades and construction projects during FY 2019, including the repair of multiple docks and shorelines at the spaceport. The shoreline at the Turn Basin near Kennedy's News Center and the Vehicle Assembly Building (VAB) has been restored to protect from further erosion, and docks are being reconstructed in the KARS Park I marina. The security marine patrol dock adjacent to the Roy Bridges Bridge in the Banana River, which separates Kennedy from nearby Cape Canaveral Air Force Station, also will be reconstructed.

Kennedy's new headquarters building, which anchors the spaceport's Central Campus, opened its doors to the workforce in April 2019. Engineering oversaw the construction of the seven-story, 200,000-square-foot facility, which provides workspace for approximately 500 NASA and contractor employees, including shared services such as the center's post office. The building's sustainable features, including occupancy sensor-controlled LED lighting, windows and screens designed to maximize natural light, chilled beam HVAC technology and more, have earned it the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Gold designation.

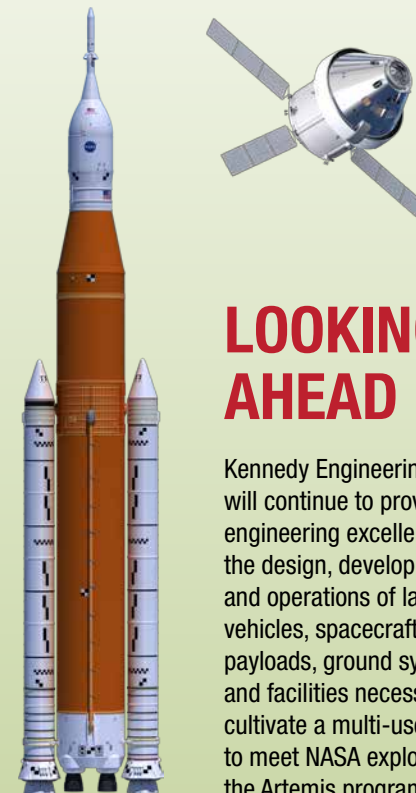


## CENTRAL CAMPUS



## UTILITY ANNEX

Engineering also is repairing and upgrading the Utility Annex to prepare the facility for NASA's Artemis missions. The annex provides chilled and hot water to the VAB, and also provides a secondary loop of water to several other facilities in Kennedy's Launch Complex 39 area. The chilled-water supply serves a critical role in the facilities' heating, ventilation and air-conditioning systems (HVAC), necessary for cooling buildings and equipment.



## LOOKING AHEAD

Kennedy Engineering will continue to provide engineering excellence in the design, development and operations of launch vehicles, spacecraft, payloads, ground systems and facilities necessary to cultivate a multi-user spaceport while advancing transformational space technologies to meet NASA exploration goals. The Engineering team also will continue supporting the Artemis program as well as NASA's commercial partners.





# SPACEPORT INTEGRATION AND SERVICES

## Running America's Premier Multi-User Spaceport

### Gold Standard

Kennedy's environmental team received the highest score ever earned by any NASA center on the agency's tri-annual environmental and energy/water functional review. The center's score – almost all “green” on all elements in the audit's focus areas – highlights Kennedy's environmental expertise and commitment to stewardship and sustainability.

### SETTING THE PACE

FY18 Launches  
19

FY19 Launches  
17

FY20 Launches Forecast  
39



Spaceport Integration and Services (SI) supports all launches from the spaceport – a total of 17 launches in FY 2019. These missions supported NASA's Commercial Crew and Launch Services Programs, FAA-licensed commercial launches and flights on behalf of the U.S. Department of Defense. The SI team also is preparing to support launches from Launch Complex 48 after construction is complete.



### Did you know?

All NASA centers are now required to use the agency's Propellants Product Service Line provided by the Kennedy Propellants and Life Support branch, which has responsibility for NASA-wide aerospace fluids acquisition and management.

In 2016, Hurricane Matthew caused significant erosion to Kennedy's natural beach and dune. The spaceport launched the Shoreline Restoration Project to protect critical launch infrastructure by restoring 3.5 miles of coastline to its natural state. As of FY 2019, about 450,000 cubic yards of beach sand has been added to rebuild the dune, and native vegetation has been planted to stabilize it and offer a habitat for coastal wildlife.



### THE BUSINESS

### of the SPACEPORT

#### P R O J E C T S

- Replaced roof on Fire Station No. 1 and windows in Launch Control Center firing rooms
- Replaced fire suppression systems in the Reusable Launch Vehicle hangar used by Space Florida
- Completed repairs that remained after Hurricane Matthew
- Replaced cover on “clamshell” storage facility
- Upgraded critical heating, ventilation and air-conditioning (HVAC) systems throughout the spaceport
  - » Replaced HVAC systems in Astronaut Crew Quarters, located inside the Neil Armstrong Operations and Checkout Building
  - » Replaced HVAC in the Columbia Artifact Room, located inside the Vehicle Assembly Building
  - » Replaced chiller for Hypergolic Maintenance Facility Support Building
  - » Replaced HVAC in Crawler Transporter Maintenance Facility
- Replaced Mid-Course Radar Condenser Units 7 and 8
- Verification and validation activities for NASA's Exploration Ground Systems
- Ascent Abort-2 generator support at Cape Canaveral Air Force Station's Launch Complex 46





Kennedy's Fire Department received a new Aircraft Rescue and Fire Fighting (ARFF) vehicle in FY 2019, replacing a 28-year-old version.



Protecting the spaceport's world-class workforce, facilities and assets requires unwavering vigilance. In FY 2019, as it does every year, Kennedy's Protective Services team practiced for worst-case scenarios, including a full-scale, realistic hostage negotiation exercise.

### HOSTAGE NEGOTIATION EXERCISE

SI established a mid-year review of Kennedy's entire vehicle fleet in order to evaluate how they are used and to prepare for annual requests and replacements to the General Services Administration (GSA). These regular, timely reassessments, held for the first time in FY 2019, will help ensure the spaceport makes the best use of its vehicles.

As one of the center's contracts came to an end, SI transitioned the contractor's GSA vehicles: 162 were returned to GSA for sale at auction, 39 were transferred to other NASA centers, and the rest were put to use elsewhere at Kennedy. This effort resulted in an overall 28% reduction in Kennedy's GSA vehicle fleet.

## GSA Vehicle Fleet



The spaceport replaced **THREE** of its emergency vehicles with state-of-the-art models to enhance its security posture at the growing, multi-user spaceport.

# 2nd

Kennedy's Emergency Response Team placed **SECOND OVERALL** out of 54 teams from around the world in the 2018 SWAT Roundup International Competition.

## Working Together



As the center's provider of propellants and other commodities, SI participated in two SLS Artemis I scrub turnaround liquid hydrogen (LH2) pathfinder tests. These tests ensure there will be enough LH2 in the Launch Complex 39B fuel storage sphere to allow a 48-hour scrub/turnaround and second launch attempt.



Kennedy continues to advance its solar-power capabilities in the center's Industrial Area. A newly constructed 1.98-megawatt photovoltaic facility brought online this fiscal year is expected to make phase 1 of the new Central Campus headquarters building net-zero for energy – and raise Kennedy's total energy consumption from renewable sources up to 7-8%. The spaceport already is planning additional solar-power expansions.



SI and Exploration Ground Systems (EGS) began testing on the Launch Pad 39B Ignition Overpressure Protection and Sound Suppression System on July 2, 2019. Designed by SI in coordination with experts at other NASA centers, the system posed unique challenges due to the high volume of water flows in close proximity to flight hardware, as well as very specific integration requirements. It will protect NASA's Space Launch System (SLS) rocket from the acoustic energy generated during liftoff.

# 40+ TIMES

The Protective Services Office Emergency Management team activated the Emergency Operations Center over 40 times in FY 2019 to support launches, special events, two visits by Vice President Mike Pence, and hurricanes.



# Communication and Public Engagement

Members of the media descended on Kennedy Space Center to take part in 43 media projects throughout FY 2019. In addition to individual media projects, media events, launches, Apollo 50th celebrations and a visit from the vice president brought over 1,000 journalists to the center.

Millions of people all over the world were engaged online through several Kennedy social media channels. Nine NASA Socials took place, which brought in almost 400 participants to observe a launch, hear a Moon to Mars address from the NASA administrator, or participate in an event for podcasters.

In recognition of the interactivity of the SpaceX Demo-1 mission campaign, Kennedy's Public Affairs team was recognized at the Creative Arts Emmy Awards in Los Angeles, California, where the team took home the Emmy for Outstanding Interactive Program.

The center's Academic Engagement team welcomed over 130 interns throughout the fiscal year. The team also hosted a virtual version of the Robotic Mining Competition (RMC), with 51 teams competing, while the on-site arena was under construction. RMC has now changed its name to Lunabotics, to reflect the program's future evolution beyond a mining competition.

NASA's Established Program to Stimulate Competitive Research (EPSCoR) conducted five solicitations and awarded 100 cooperative agreements in FY 2019. Additionally, the program published the 2018-2019 edition of *Stimuli*, a publication that highlights research demonstrating how EPSCoR supports the agency's efforts to return to the Moon and then venture on to Mars.

The NextGen STEM program focuses on four themes: Small Steps to Giant Leaps, Commercial Crew Program (CCP), Moon to Mars and STEM on Station. Each offers unique learning activities, tools and resources aligned to Next Generation Science Standards. The Kennedy team has completed the pilot phase for Virtual Reality content and curriculum.



*Dr. Lucie Low of the National Institutes of Health talks to NASA Social participants about the Tissue Chips in Space project on April 29, 2019, during a science briefing for the SpaceX CRS-17 mission.*

NASA's Swarmathon competition was held in June 2019. The "swarm robotics" programming challenge is administered under a cooperative agreement between NASA's Minority University Research and Education Project and the University of New Mexico, in partnership with a Kennedy subject matter expert and the center's STEM Engagement office. This year's competition was hosted at the university, while the robotics workshop and culminating event were held at Kennedy Space Center Visitor Complex. This is the final year of the competition.

NASA Community College Aerospace Scholars (NCAS) Workshop is an on-center, week-long workshop for community college students who have successfully completed a five-week online course from the agency's Johnson Space Center in Houston. Kennedy hosted two NCAS workshops; students worked in teams, mentored by Kennedy engineers, competing in LEGO rover challenges to win a fictitious NASA contract.

The multi-day NASA Days at Minority Serving-Institutions allows students attending these institutions to engage one-on-one with NASA managers and learn about agency internships, fellowships, Pathways



*Courtney Miller, a student at Langston University in Oklahoma, participates in a hands-on experience inside Kennedy's Space Station Processing Facility lab on Sept. 18, 2019. Miller was part of a tour of the Florida spaceport organized by NASA's Office of STEM Engagement and Langston.*



*Members of the news media gather near Kennedy's countdown clock to record the remarks of NASA Administrator Jim Bridenstine, at the podium, during an Apollo 11 Media Day on May 23, 2019. At left is Center Director Bob Cabana.*



and other student opportunities, and allows NASA to foster relationship-building with the host institution. Schools visited in FY 2019 were Bethune-Cookman University, Florida International University, Navajo Technical University and North Carolina A&T State University.

In FY 2019, the Outreach (PX-0) team supported several launches and welcomed more than 8,400 guests for the missions. In addition to launches, the organization managed 31 employee events with over 3,000 attendees. Kennedy's Speakers Bureau supported 300 events last year, reaching about 55,000 people.

Along with employee events, the team managed nine distinguished visitor events, including those attended by Elaine Chao, secretary of U.S. Department of Transportation; Treasury Secretary Steven Mnuchin; and Vice President Mike Pence, who spoke at an event marking the 50th anniversary of Apollo 11.

The Center Exhibits Program attended 16 events, reaching more than a million people. This year, the Exhibits team attended events in areas where there's less NASA exposure, ensuring the agency's story is told to people who may not seek it out and broadening awareness of Kennedy's multi-user spaceport.



Secretary Elaine L. Chao of the U.S. Department of Transportation (DOT) speaks to center leadership about the DOT's role in enabling commercial space during a spaceport visit on April 24, 2019.

The Allstate Tom Joyner Family Expo, led by Kennedy, served as an interagency collaboration with the Center Exhibits Programs and Offices of Communications at NASA Headquarters in Washington, Marshall Space Flight Center in Alabama and Stennis Space Center in Mississippi.

The Digital Expansion to Engage the Public team supported 30 digital events, reaching approximately 124,000 people.

The VIP tour team coordinated over 364 tours, enabling more than 7,000 guests to safely see behind the scenes at the spaceport. Tour participants included VIP guests, educational groups, government officials and NASA contractors and partners.



Employees listen to a panel discussion regarding NASA's Moon to Mars plans on Aug. 28, 2019. Seated from left are Tom Joyner, national radio host; Charlie Bolden, former NASA administrator and astronaut; Kim Carter, Exploration Ground Systems associate manager, technical; Barbara Brown, Kennedy chief technologist; former astronaut Winston Scott; and panel co-host Sybil Wilkes.



Crowds of spectators watch from Jetty Park in Cape Canaveral, Florida, as a Northrop Grumman-provided booster and a test version of the Orion spacecraft lift off from Launch Pad 46 on NASA's Ascent Abort-2 mission.



# Business Report

The Kennedy Space Center Fiscal Year 2019 budget was \$1.9 billion. The center also performed \$174 million in reimbursable work with other government and commercial entities.

NASA's Commercial Crew Program completed its first uncrewed flight test in FY 2019, advancing the agency's goal of returning human spaceflight launches to U.S. soil on commercially built and operated American rockets and spacecraft. Along with its commercial partners, Boeing and SpaceX, the program is preparing to fly astronauts to the International Space Station on U.S.-built vehicles launched from U.S. soil.

In March, the world witnessed SpaceX's Demo-1 mission, an uncrewed flight test of Crew Dragon that launched aboard a Falcon 9 rocket to the International Space Station and autonomously docked to the station. After five days, it returned to Earth, splashing down in the Atlantic Ocean. Demo-1 demonstrated SpaceX's crew transportation system capabilities and brought the program a significant step closer to launching crew once again from Florida's Space Coast.

Boeing completed initial production of three CST-100 Starliner spacecraft inside the company's Commercial Crew and Cargo Processing Facility at Kennedy, and conducted environmental qualification testing to validate Starliner's ability to withstand the harsh environments of launch, ascent and spaceflight. Starliner's propulsion system was put to the test at White Sands Test Facility in New Mexico during an integrated service module hot fire test. Boeing also completed the initial qualification series of parachute drop tests using a high-altitude balloon, and working with NASA, completed a series of lawn dart drop tests to continue proving the reliability of Starliner's parachute systems. Boeing, United Launch Alliance (ULA), NASA and the Department of Defense (DoD) teamed up for integrated rehearsals of mission phases and various emergency escape and recovery scenarios. Crew training for the Crew Flight Test and first operational mission also continues, and mission teams began their mission dress rehearsals for various phases of the upcoming missions.

The ULA Atlas V rocket that will launch Starliner on its uncrewed Orbital Flight Test arrived in Cape Canaveral, Florida, and is ready for final integration before launch. The Atlas V set to launch astronauts on Boeing's Crew Flight Test also arrived in Florida for processing ahead of the mission.

SpaceX continued manufacturing its Crew Dragon spacecraft inside its headquarters facility in Hawthorne, California. The company conducted a series of parachute tests that provided unique insight into parachute loading, behavior and reliability, and helped to further refine parachute design.

Teams from NASA, SpaceX and the DoD continued to rehearse launch day operations, mission phases and communication in both normal and emergency scenarios. Teams also practiced removing astronauts from Crew Dragon on the company's recovery boat, rehearsing steps they will take after splashdown of SpaceX's Demo-2 mission, which will be the company's first with crew aboard.

The nine U.S. astronauts selected for commercial crew missions worked closely with Boeing and SpaceX to ensure they are prepared for any situation that may arise during their mission and to live and work aboard the space station.

Upcoming flight test dates for each provider are under review. Following each

test, NASA will review the performance data to ensure each upcoming mission is as safe as possible. After completion of all test flights, NASA will continue its review of the systems and flight data for certification ahead of the start of regular flights with crew to the space station.

During FY 2019, the Launch Services Program (LSP) supported one successful launch. The Venture Class Launch Services (VCLS) mission, designated Educational Launch of Nanosatellites (ELaNa)-19, launched on Dec. 16, 2018, and marked the first time that NASA CubeSats received a dedicated ride to orbit on a commercial launch vehicle. LSP procured launch vehicle services for three manifested missions: Imaging X-ray Polarimetry Explorer (IXPE), Double Asteroid Redirection Test (DART) and Lucy. IXPE has three identical telescopes designed to measure the polarization of cosmic X-rays and is planned to launch in April 2021; DART is a planned NASA space probe that will demonstrate kinetic impactor technology and is planned to launch in July 2021; and Lucy is a planned NASA space probe that will tour five Jupiter Trojans and is planned to launch in October 2021. LSP procured two rideshare opportunities: Integrated Multi-Mission Carrier (IMMC-1) was added to Landsat-9 and Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) was added to JPSS-2. Additionally, LSP is providing mission integration and advisory services for more than 60 NASA missions.

Exploration Ground Systems (EGS) managed both EGS and the 21st Century Space Launch Complex funding as it readies the spaceport to support a human presence on the Moon with the ultimate goal of sending astronauts to Mars. The EGS budget contained the funding for the award of the Mobile Launcher 2 design-build contract, and the modernization efforts in support of the Artemis I launch of the Space Launch System rocket and the Orion spacecraft. Key accomplishments include rollout of the mobile launcher from the Vehicle Assembly Building to Launch Pad B, and a successful Ascent Abort test of Orion's Launch Abort System. In addition, support continued for the mobile launcher and VAB multi-element validation and verification, Pad B modernization, including the liquid hydrogen sphere upgrades, and development of the Spaceport Command & Control System. Enhancements of Kennedy's multi-user spaceport continued for the development of ground operations infrastructure to facilitate the activities of future customers and stakeholders, including government agencies, commercial industry, and current and future NASA programs.

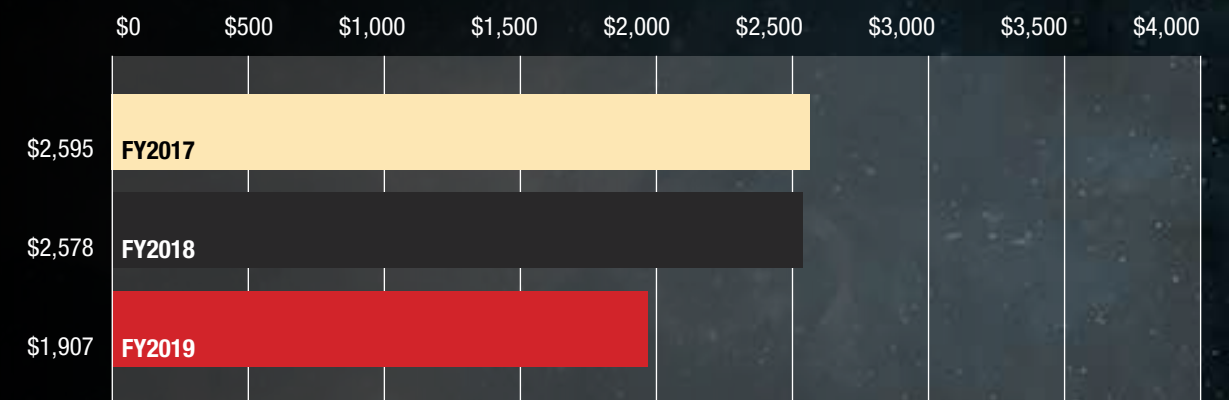
The International Space Station Program allowed for continued success toward achieving and maintaining the space station program mission of fully utilizing a permanent human outpost in space. Kennedy's mission efforts afforded provisions for ground processing support for experiments hardware, as well as orbital replacement units needed to maintain the space station. The budget also provided for ongoing development of hardware intended to promote full utilization of the space station through the establishment of fundamental biological research capabilities.

Kennedy's Center Management and Operations Program budget maintained the center's essential infrastructure, its core technical capabilities, and sustained necessary safety and engineering technical authorities to support NASA's mission and enable multi-user spaceport readiness.

## KENNEDY SPACE CENTER FY 2019 BUDGET AUTHORITY (\$ IN MILLIONS)

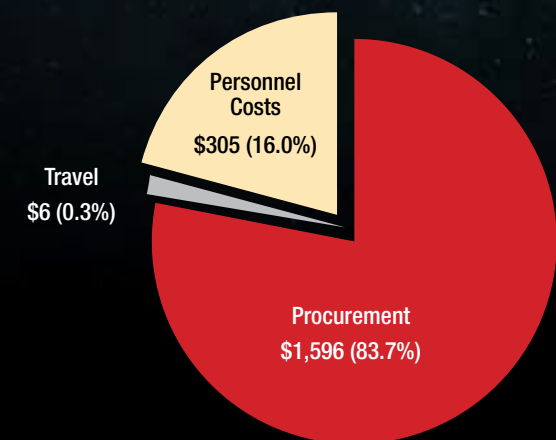
Commercial Crew Program	\$481
Launch Services/Science	\$357
Exploration Ground Systems	\$537
Space Station	\$55
Center Management & Operations	\$324
Other	\$153
<b>Total KSC</b>	<b>\$1,907</b>

## NASA/KSC BUDGET AUTHORITY SUMMARY FY 2017 THROUGH FY 2019 (\$ IN MILLIONS)



## FY 2019 KSC BUDGET BY ELEMENT (\$ IN MILLIONS)

TOTAL \$1,907





# Workforce Overview

Kennedy Space Center is the nation's premier, multi-user spaceport. It is an integral part of the local economy, providing more than 10,000 jobs for civil servants, contractors, tenants and construction crews.

The workforce includes people with many skills who are dedicated to supporting the nation's space program and NASA's future exploration to destinations including the Moon and Mars. To accomplish the agency's various missions, these individuals fulfill a multitude of tasks.

At the end of each year, the center takes a snapshot of its workforce. This picture includes all federal and contractor employees chartered to work for Kennedy. Other organizations, such as the European Space Agency and Patrick Air Force Base, have roles here but are not reflected in these numbers.

The civil servant skill mix includes those in science, technology, engineering and mathematics positions and those in professional administrative and clerical positions.

## KENNEDY SPACE CENTER WORKFORCE PROFILE (through 9/30/19)

Civil Servants	1,990*
NASA Pathways Interns	87
<b>Total Civil Servants</b>	<b>2,077</b>
*includes 1 recent graduate, 7 full-time term employees and 11 part-time permanent employees	
<b>Civil Servants Skill Mix</b>	
Scientific, Technology, Engineering and Mathematics	32%
Clerical and Professional Administrative	68%
<b>On-site Contractor Employees</b>	<b>4,761</b>
Off-site/Near-site Contractor Employees (Excludes construction workers)	83
<b>Total Contractor Employees</b>	<b>4,844</b>
<b>Total Construction Workers</b>	<b>444</b>
<b>Total Tenants</b>	<b>2,785</b>
<b>TOTAL KSC POPULATION</b>	<b>10,150</b>

# Procurement Report

## INDUSTRY PARTNERS AT A GLANCE

The companies listed below were some of Kennedy Space Center's top support or launch services contractors in terms of dollars obligated in FY 2019. Following is a brief description of their work for the agency.

### AECOM Management Services Inc.

AECOM provided laboratory support services and operations for Kennedy Space Center. AECOM was responsible for the operation, maintenance and engineering for a diverse set of laboratories, developmental shops and test facilities. AECOM also was responsible for program management, laboratory maintenance and support, operational laboratory services, and professional and technical support for scientific research, engineering analysis, test and evaluation in laboratory environments.

### Bechtel National Inc.

Bechtel National Inc. is the prime contractor for the design and construction services for Exploration Ground Systems' Mobile Launcher 2 (ML2). Bechtel is responsible for the design, construction, testing and commissioning of the ML2. The ML2 is necessary to meet NASA's goal of returning men and landing the first woman astronaut on the Moon by 2024.

### The Boeing Company

The Boeing Company participated in NASA's goal of developing orbital Commercial Crew Transportation Systems. Under the Commercial Crew Transportation Capability (CCTCap) contract for NASA's Launch America initiative, The Boeing Company was tasked with developing safe, reliable and cost-effective crew transportation to and from the International Space Station on American spacecraft launched from the United States.

### Space Exploration Technologies Corp.

Space Exploration Technologies Corporation (SpaceX) participated in NASA's goal of developing orbital Commercial Crew Transportation Systems. Under the CCTCap contract for NASA's Launch America initiative, SpaceX was tasked with developing safe, reliable and cost-effective crew transportation to and from the space station on American spacecraft launched from the United States.

### United Launch Services LLC

United Launch Services, or ULS, a subsidiary of United Launch Alliance, is a joint venture between The Boeing Company and Lockheed Martin Commercial Launch Services. ULS provided commercial launch services to NASA using the Delta and Atlas launch vehicles under the NASA Launch Services (NLS) II multiple-award, indefinite delivery, indefinite quantity task order contract. Principal location for the Delta and Atlas vehicle assembly is Decatur, Alabama. Both vehicles launch from Cape Canaveral Air Force Station in Florida and Vandenberg Air Force Base in California.

### Jacobs Technology Inc.

Jacobs Technology Inc., prime contractor for the Test and Operations Support Contract (TOSC), is responsible for the overall management and implementation of ground systems capabilities, flight hardware processing and launch operations at Kennedy. Specific services provided by Jacobs Technology under TOSC include launch vehicle, spacecraft, and payload integration and processing; operations and development of associated processes for ground systems to support integration, processing and launch; servicing and testing of flight hardware; and launch of development and operational flights at Kennedy.



## YOUR PROCUREMENT DOLLARS AT WORK GEOGRAPHICAL DISTRIBUTION BY STATE (Fiscal Year 2019 Obligations)

STATE	TOTAL DOLLARS
ALABAMA	12,335,296
ARIZONA	463,127
CALIFORNIA	257,632,531
COLORADO	213,056,865
CONNECTICUT	1,960,812
DISTRICT OF COLUMBIA	485,191
FLORIDA	137,009,999
GEORGIA	2,639,175
IDAHO	12,810,537
INDIANA	2,235,477
LOUISIANA	30,903,931
MARYLAND	192,245,316
MICHIGAN	746,972
MISSOURI	1,715,263
MONTANA	7,340

STATE	TOTAL DOLLARS
NEW HAMPSHIRE	744,263
NEW MEXICO	11,756,664
NEVADA	60,000
NEW YORK	872,247
NORTH CAROLINA	765,030
OHIO	18,376,441
OREGON	336,119
PENNSYLVANIA	25,039,497
SOUTH CAROLINA	18,797
SOUTH DAKOTA	668,169
TENNESSEE	324,832,220
TEXAS	242,285,352
VIRGINIA	392,242,160
WISCONSIN	1,017,539
<b>TOTAL</b>	<b>\$1,885,262,330</b>

## TOP 25 KSC BUSINESS CONTRACTORS FOR FY 2019

Contractor	Dollars
JACOBS TECHNOLOGY INC.	320,012,173
BECHTEL NATIONAL INC.	296,658,688
SPACE EXPLORATION TECHNOLOGIES CORP.	240,344,890
THE BOEING COMPANY	232,733,224
UNITED LAUNCH SERVICES LLC	212,393,734
AECOM MANAGEMENT SERVICES INC.	111,524,004
ASRC FEDERAL DATA SOLUTIONS INC.	43,212,222
PAE-SGT PARTNERS LLC	42,840,562
J.P. DONOVAN CONSTRUCTION INC.	37,677,068
AI SOLUTIONS INC.	35,525,304
HEALTHION INC.	28,825,077
CHENEGA INFINITY LLC	23,190,136
INTEGRATED MISSIONS SUPPORT SERVICES LLC	21,096,935
DAVENPORT AVIATION INC.	18,262,569
MILLENNIUM ENGINEERING AND INTEGRATION CO.	17,601,625
NORTH WIND CONSTRUCTION SERVICES INC.	12,810,538
FLORIDA POWER AND LIGHT COMPANY INC.	12,124,122
TETRA TECH INC.	12,089,628
APACHE-LOGICAL JV	11,805,039
REYNOLDS SMITH AND HILLS INC.	10,384,268
A-P-T RESEARCH INC.	9,991,019
AIR LIQUIDE LARGE INDUSTRIES U.S. LP	9,642,622
NEW DIRECTIONS TECHNOLOGY CORP.	8,864,814
AIR PRODUCTS AND CHEMICALS INC.	8,379,305
BREVARD ACHIEVEMENT CENTER INC.	7,224,461
<b>TOTAL</b>	<b>1,785,214,027</b>





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Public Affairs Directorate

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